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Self-Flipped Classroom

Reuse of Student-Produced Videos for Flipped Classrooms

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Abstract

The cultures of social media and prosumerism enter the domain of modern education and power a shift towards learner-centred active learning with a focus on learning through making in nearly every subject, discipline and level of teaching. Keeping pace with these changes requires pedagogical innovation and motivates us to develop and evaluate a new instructional and learning approach that is built on the reuse of student-produced content.

This research has defined such a pedagogical approach, the Self-Flipped Classroom, built on the synergy of *Flipped Classroom* and *learning through making* pedagogies. In the proposed approach, the *self-* part of the name refers to materials that students produce as part of their own learning; and the *-flip* part of the name refers to reuse of these materials by instructors for teaching other students in the flipped classroom pedagogical model. This thesis presents the Self-Flipped Classroom both from theoretical and practical viewpoints, and discusses the experience of implementing the approach in courses related to Human-Computer Interaction discipline in two universities (Newcastle University, UK and Uppsala University, Sweden).

The main contribution of this work is twofold. First, theoretical – in terms of the positioning of the new pedagogy within existing theories and pedagogical approaches. Second, practical – in presenting the testing and evaluation of two variants of the approach (the Distributed and the Enclosed Self-Flipped Classrooms) in real case studies. Anyone who is interested in trying the approach in their own practice will find the results of the presented case studies to be informative from two perspectives: a) student attitudes to and experiences of the Self-Flipped Classroom; b) associated benefits and challenges of the Self-Flipped Classroom for instructors.

As part of the investigation of student experiences of the presented approach, this thesis explores lifelong learning skills development (media literacy, collaboration, attribution and others) that are found amid other benefits for students who engage with the Self-Flipped Classroom. The presented research has been conducted in the context of Computer Science education, however, the presented results, and particularly the proposed Self-Flipped Classroom approach, can be applicable to other disciplines.

Publications

Aspects of the research presented in this thesis have been published in peer-reviewed venues prior to the submission of this thesis. These are listed in reverse chronological order below:

- **A. Vasilchenko,** Å. Cajander and M. Daniels. 2020. Students as Prosumers: Learning from Peer-Produced Materials in a Computing Science Course. In *Proceedings of IEEE Frontiers in Education Conference (FIE), Uppsala, Sweden, 2020.* https://doi.org/10.1109/FIE44824.2020.9274042
- **A. Vasilchenko**, M. Venn-Wycherley, M. Dyson, and F. Russo-Abegão. 2020. Engaging Science and Engineering Students in Computing Education through Learner-Created Videos and Physical Computing Tools. In *Proceedings of ACM Computing Education Practice conference (CEP'20), January 9, 2020, Durham, United Kingdom.* ACM. https://doi.org/10.1145/3372356.3372372
- A. Wilde, **A. Vasilchenko,** A. Dix, C. Evans, J. Maguire, and S. Snow, (2019). Towards a Taxonomy of Video for HCI Education. In León-Urrutia, M., Vázquez Cano, E., Fair, N., López Meneses, E. (eds.) *Trends and Good Practices in Research and Teaching. A Spanish-English Collaboration.* Barcelona: Octaedro. https://doi.org/10.36006/16184-02
- **A. Vasilchenko,** G. Tarawneh, H. Qarabash, and M. Balaam. 2018. Collaborative Content Creation: Impact of Media Type on Author Behavior. In *Proceedings of the 21st ACM conference on Computer Supported Cooperative Work and Social Computing - CSCW '18 Companion*. https://doi.org/10.1145/3272973.3274092
- **A. Vasilchenko,** M. Daniels, Å. Cajander, and M. Balaam. 2018. The Self-Flipped Classroom Concept: Underlying Ideas and Experiences. In *Proceedings of IEEE Frontiers in Education Conference (FIE), San Jose, CA, USA, 2018.* https://doi.org/10.1109/FIE.2018.8658616
- **A. Vasilchenko** and A. Wilde. 2018. Self-Flip: How Learning through Making Can Flip the Classroom. In *Proceedings of the ACM WomENcourage 2018, 24 - 26 Oct, Belgrade, Serbia 2018*.
- **A. Vasilchenko,** A. Wilde, S. Snow, M. Balaam, and M. Devlin. 2018. Video Coursework: Opportunity and Challenge for HCI Education. In *Proceedings of the 2018 ACM International Conference on Advanced Visual Interfaces* http://dx.doi.org/10.1145/3206505.3206596
- **A. Vasilchenko**. 2017. Self-Flipped Learning & Teaching for STEM in Higher Education. In *Proceedings of 15th European Conference on Computer-Supported Cooperative Work - Doctoral Colloquium*. European Society for Socially Embedded Technologies (EUSSET). http://dx.doi.org/10.18420/ecscw2017_dc7
- **A. Vasilchenko,** D. Green, H. Qarabash, A. Preston, T. Bartindale, and M. Balaam. 2017. Media Literacy as a By-Product of Collaborative Video Production by CS Students. In *Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education*. ACM. http://dx.doi.org/10.1145/3059009.3059047

Furthermore, this research has led to contribution to the organisation of the following workshops and Special Interest Group meeting:

- C. MacDonald, O. St-Cyr, C. Gray, L. Potter, J. Sin, **A. Vasilchenko,** and E. Churchill. 2021. EduCHI 2021: 3rd Annual Symposium on HCI Education. *In Extended Abstracts of the 2021 CHI Conference on Human Factors in Computing Systems (CHI EA'21), Yokohama, Japan* https://doi.org/10.1145/3411763.3441320
- O. St-Cyr, C. MacDonald, C. Gray, L. Potter, **A. Vasilchenko,** J. Sin, and E. Churchill. 2020. EduCHI 2020: 2nd Annual Symposium on HCI Education. *In Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA'20), Honolulu, HI, USA* https://doi.org/10.1145/3334480.3375066
- **A. Vasilchenko,** J. Li, B. Ryskeldiev, S. Sarcar, Y. Ochiai, K. Kunze, and I. Radu. 2020. Collaborative Learning & Co-Creation in XR. *In Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems (CHI EA'20), Honolulu, HI, USA* https://doi.org/10.1145/3334480.3381056
- A. Wilde, **A. Vasilchenko** and A. Dix. 2018. HCI and the Educational Technology Revolution #HCIEd2018 – A full-day workshop on video-making for teaching and learning Human-Computer Interaction. In *Proceedings of the 2018 ACM International Conference on Advanced Visual Interfaces.* http://dx.doi.org/10.1145/3206505.3206600

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Chapter 1. Introduction

1.1 Overview

This thesis presents a new pedagogical approach, called *Self-Flip Classroom*, and evaluates the experience of implementing it in practice by two case studies conducted at Newcastle University, UK, and Uppsala University, Sweden. This chapter provides a brief overview of the presented research, including motivation, main definitions and research questions, and outlines the structure of the rest of the thesis.

The research is driven by the ongoing shift towards learner-centred active learning, which can be witnessed across different disciplines, and the increased emphasis on equipping students with *lifelong learning skills*, also referred to as *transferable* or *21st century skills*, which include, among others, problem-solving, critical thinking, creativity, and various digital literacies. One way to ensure that students acquire lifelong learning skills is to engage them in active learning through *student-centred pedagogy* (Boyer, 1990). Since effective pedagogies usually follow current societal trends (in order to be more practical and also appealing to students), educators need to continuously update and revise them. In an attempt to do so, this research aims at designing and evaluating a new form of student-centred pedagogy, which is built on such contemporary active learning approaches as *Flipped Classroom* (Bergmann & Sams., 2012), *peer learning* (Topping & Ehly, 1998), and *learning through making* (Hsu et al., 2017).

The developed pedagogical approach is widely applicable, however, due to limited resources of the PhD project, the presented investigation focused only on the Science, Technology, Engineering and Mathematics (STEM) subjects, and the two case studies were conducted as part of Computer Science courses, with a focus on Human-Computer Interaction (HCI) discipline. The next Section 1.2 provides the motivation for choosing HCI as a suitable experimental ground. It is followed by Sections 1.3 and 1.4, which introduce the main ideas behind the Self-Flipped Classroom (SFC) pedagogy and definitions of relevant educational concepts. Section 1.5 develops the research questions to guide the case studies, and Section 1.6 concludes this chapter with an overview of the thesis structure and a statement of the main contributions of this work.

1.2 Motivation and Research Focus

While I strongly believe that the Self-Flippped Classroom pedagogical approach is suitable for teaching any subject or discipline, the limited timeframe and resources of my PhD project forced me focus my investigation on a small set of case studies. Furtunately, I was able to find several teaching teams keen to collaborate on this research, who were primarily teaching HCI-related Computer Science and Engineering courses. This was an excellent fit for my investigation due to the complexity and multidisciplinarity of the HCI field. Teaching and learning HCI is not a trivial task because of the ever-growing complexity of the field. As Churchill et al. (2013) articulate, today's educational institutions should aim at preparing *HCI progressionals* in order to deal with the unpredictable future in the field:

> *"The new issues emerging from the development of new technologies and a continually expanding user population require HCI progressionals: practitioners, researchers, and educators who are willing to keep step with technological progress and master new design and evaluation methods and new technical competencies while maintaining the professional and intellectual values, tenets, and perspectives that are unique to our field."* (Churchill et al., 2013, p.46)

This quote suggests that a successful HCI graduate is the one who had not only learned how to memorise facts and operate with universal algorithms, but the one who had developed a set of life-long learning skills to keep up with new principles and methods, and strive for innovation; the one who had built a foundation of personal values (such as empathy, tolerance, sensitivity to diversity, and bias awareness) that underpin HCI; and the one who had acquired the ability for appreciation of other cultural and professional values present in multifaceted user contexts. In fairness, it is worth noting that all of these merits do not go against any other subject or discipline taught in universities, and any modern university graduate should strive to develop this wide range of transferable skills.

Fostering these skills requires non-trivial forms of education and instruction, and educators are therefore searching for innovative ways of teaching and learning in order to prepare their students for the demands and complexity of the today's world (Sears et al., 1997; Gallivan et al., 2004; Trilling & Fadel, 2012). The objective of my research is hence to develop and test a new pedagogical model that has a potential to help students develop these skills. This new model builds on the best practice of existing approaches that already proved effective for this task, such as experiential and collaborative learning. Inspired by the above quote, the proposed pedagogy puts a specific emphasis on teaching students a range of transferable skills that should help them become “progressionals” in the field they have chosen.

1.3 Towards a New Pedagogical Model

The development of a new pedagogy was approached with two perspectives in mind: (i) the complexity and dynamics of the HCI discipline; (ii) the current societal trends that impact education, specifically the popularity and increasing uptake of the *Flipped Classroom* and *learning through making* pedagogies as well as the trend of *prosumerism*.

The cognitive theories of *constructivism* and *social-cultural constructivism* have long been the bedrock of modern education. In *constructivism* theory, Piaget advocates that the knowledge is actively constructed by a learner through the contact with the world (Piaget, 1967). Vygotsky extends this idea by emphasising a very important element – the *social and cultural context* of learning, inferring that learner’s cognitive development is inherently collaborative (Vygotsky, 1978). Over the last half century, theorists and practitioners alike widely proclaimed the benefits of collaborative learning (e.g. Gokhale, 1995; Roschelle & Teasley, 1995; Stoll, 1996). As a result, we witness the ever growing popularity of diverse approaches to collaborative learning, and Flipped Classroom is one of them.

Another extention of Piagetian *constructivism* is the lerning theory of *constructionism,* articulated by Paper in 1980s, which posits that best learning is happening when learners produce constructions that others can see and critique (Papert & Harel, 1991). The two major features of *constructionism* are: creation of an artefacts as a result of a learning process, and sharing of this artefacts with others.

The Flipped Classroom (FC) pedagogy was developed about a decade ago as an effective approach to maximise time for learning and instruction – “the scarcest learning resource” (Tucker, 2012). By replacing face to face lecturing with at home learning of theoretical concepts from videos and other materials, and thus freeing in-class time for active learning exercises, FC opens opportunities for more efficient instruction. At its base, FC is only a structural model for organising learning activities, so it does not dictate any particular variant of active learning for the in-class use, and therefore can be combined with other pedagogical approaches to facilitate student in-class work.

One such approach, which is increasingly being regarded as an effective tool in the hands of progressive educators, is *learning through making* (Blikstein, 2013; Hsu et al., 2017). Today's democratisation of personal technology made learning through creation of digital and digitally-fabricated physical artefacts an appealing and accessible pedagogical approach. Building on the learning theory of *constructionism* (Papert, 1986), learning through making emphasises increased learner motivation and engagement (Kafai et al., 2014), development of life-long learning skills such as creativity, problem-solving and innovation (Honey & Kanter, 2013), as well as more specific professional skills (Baleshta et al., 2015) and promotion of deeper content understanding (Bevan et al., 2015).

The final component of this research is *prosumerism* (Toffler, 1980), which is a form of collaborative and peer learning, when learner-produced content is being reused to teach other students, thus turning the students both into producers and consumers (i.e. *prosumers*) of instructional materials. An approach prompted by the popularisation of social media and supported by numerous studies on effective use in educational context (Mcloughlin & Lee, 2008), prosumerism can be related to the *learning by teaching* (Martin, 1985) pedagogical method, and has a potential to support instructors in preparation of the Flipped Classroom teaching materials.

The newly proposed Self-Flipped Classroom (SFC) pedagogical approach is also grounded in the *constructionism* theory, and is developed by combining (i) a *Flipped Classroom* course structure with *learning through making* as a key learning activity, and (ii) *reuse of learner-generated content*, which facilitates reflective peer learning and collaboration, and helps instructors with the creation of FC materials. The SFC approach is inspired and influenced by many other educational paradigms, theories and approaches, and thus the very first task of this research was to position SFC within the existing and well-tested educational theories and pedagogies, explaining SFC's relationship to earlier attempts to create similar pedagogies. Building on this theoretical research foundation, I then set out to test SFC in the real world and see how two different variants of SFC work in practice, studying the perspectives of both students and instructors. To do that, I conducted two separate case studies, where students created multi-media instructional materials as part of their learning within undergraduate courses, and subsequently the created materials were reused by the instructors to teach the same student cohort (in one case study) or other student cohorts (in the other case study).

The ambition of this research is to propose an approach that will become an alternative method for the creation of instructional materials for the Flipped Classroom teaching model, and at the same time will enhance students' learning.

This research aims to contribute in the following four directions.

- The development and evaluation of the Self-Flipped Classroom pedagogical approach contributes to the theory of learning and instruction. SFC advances the ideas of *constructionism* by adding instructional video-making as a specific type of artefact creation, and by proposing a new variant of *peer learning* with the reuse of student-produced videos.
- The second contribution is to education practice. The thesis demonstrates the kind of learning the students can get from this approach, as well as the kind of challenges and opportunities the instructors can expect on the way of integrating the approach into their teaching.
- The creation of an empirically driven framework of prosumer behaviour and thinking processes in an educational context, explaining the relationship between student learning activities and their knowledge building & skills acquisition.
- The final contribution is a set of design considerations for further development of tools for supporting collaborative *learning through making* and a proposal for design of a system to support efficient delivery of the Self-Flipped Classroom courses.

1.4 Definition of the Key Concepts

The main idea of the Self-Flipped Classroom approach is that students produce reusable instructional materials as part of their own learning (the *self-* part of the name) and those materials get reused by instructors for teaching other students in the Flipped Classroom pedagogical model (the *-flip* part of the name). There is a certain flexibility in who the main actors of the approach are: the students who *produce* instructional materials and the students who *consume* (=reuse) them could belong to two or more different cohorts, or they could be *prosumers*, i.e. those who produce and consume the materials within the same course. The same goes for the instructors where the same instructor could be teaching a cohort of prosuming students, or where multiple instructors could be teaching the cohorts of producing and consuming students. To distinguish between the cases where SFC is applied within the same cohort and within a group of different cohorts, I will further use the adjectives *enclosed* and *distributed*, respectively.

Below I provide definitions of the key concepts that will be used in this thesis in relation to the Self-Flipped Classroom. Most of the terms are well-known and I only specify their meaning particularly for the context of this research. However, I also introduce here my own terms: *Distributed Self-Flip* and *Enclosed Self-Flip* that have been developed to identify two types of the Self-Flipped Classroom approach.

Self-Flipped Classroom concepts:

Artefact – a piece of student-produced material, which was created during and as part of a student's learning activity on a regular course.

Creation – the first phase of SFC, which occurs when learners create meaningful multimedia artefacts as part of their regular learning and submit them as a compulsory part of assessed coursework.

Distributed Self-Flip – a variant of SFC, where the creation and reuse phases occur in different groups of participants (artefacts creators and artefacts users).

Enclosed Self-Flip – a variant of the SFC, where both creators and users of the artefacts are from the same group of learners (that is, they belong to the same course and cohort).

Prosumption *or* ***prosumerism*** – a concept that first was introduced by Toffler in the context of marketing and economy (Toffler, 1980), and later became closely associated with social media user behaviour (Buzzetto-More, 2013; Ha & Yun, 2014). In the context of this work, this is an act of learning through creation of meaningful multimedia artefacts and the use of artefacts created by other students to learn new material during the same course. In the case studies presented here, this term will be used in relation to Enclosed Self-Flip; a student here will be an *educational prosumer*. However, educational prosumerism can also occur in the Distributed Self-Flip if the students' cohort enters the ideal SFC cycle of production and reuse, where one cohort uses the artefacts created by a previous cohort and creates equaly valuable artefacts for another cohort in future.

Reflection – is a precursor for learning, here it is an "invisible" and invaluable element of SFC where students reflect on the learning material during both phases of SFC. Inspired by Schön's definition of reflection (Schön, 1983), I present two variants of the reflection in the context of SFC: (i) *reflection-in-action* – this is an immediate form of reflection by learners during the process of artefact creation; such reflection helps to improve the process of creation of an artefact, and therefore positively impacts learning (Fessl et al., 2017); and (ii) *reflection-on-action* – this is a form of reflection that learners may experience in association with the artefacts that are ready for reuse and were created by someone else; such reflection helps to evaluate someone else's work and stimulates thinking about how and why the artefact was made the way it was, which is also aimed at improving learning. I will discuss both forms of reflection in detail in relation to the findings of this study in Chapter 7.

Reuse – the second phase of SFC, which occurs when learners study new course material, i.e. material that they do not know already, using artefacts created by other students in the first phase of SFC.

It is worth pointing out that Distributed Self-Flip is ultimately regarded as a preferable variant of SFC, as long as the students can go through both of the SFC phases, that is, the students can both create artefacts for someone else and use artefacts that were created before them. Such learning cycle can be designed for different cohorts of the same course, where last year's artefacts that went through instructor's quality control are being reused for teaching this year's students, and the students create new artefacts for the reuse in the next year's iteration of the course. This is further discussed in the Chapter 7, Section 7.1.1, dedicated to student reflection during SFC learning. See also Figure 7:2 for an illustration of ideal SFC learning cycle.

Self-Flipped Classroom pedagogical elements

For a better understanding of the "mechanics" of SFC, I list the key pedagogical elements of the approach below.

Mode of teaching: Flipped Classroom. Multimedia teaching materials are delivered to students prior to the class time, freeing the time in seminars and other interactive sessions for engaging the students in active learning activities together with their peers and the instructor. Crucially, the multimedia teaching materials are created by students.

Mode of learning: learning through making. The main learning activity that the students are engaged in during the course is creation of artefacts and reflecting on the knowledge acquired through the process of creation. The creation of artefacts is a part of the assessed coursework.

Learning outcomes: an artefact that is shareable and reusable and, more importantly, the associated skills and knowledge that the student mastered while creating the artefact. The artefact itself is a secondary outcome for the learner and is largely a means of supporting the knowledge construction and skills development. Nevertheless, it is important for the artefact to be of good quality as it is reused for teaching of other students and contributes to their learning.

The precise operational terms of the Self-Flipped Classroom pedagogical approach constitute a part of my contribution to the educational theory in addition to the new approach itself.

The next chapter will review the existing pedagogical approaches and prominent learning theories to justify why and explain how the proposed approach is going to work.

1.5 Research Questions

This research aims at the investigation of the SFC approach from two perspectives – theoretical and practical – and hence the research has two parts. The first part is led by a theoretical research question that asks for positioning of the new pedagogical approach within existing educational theories and pedagogical approaches:

RQ 1: *How is the Self-Flipped Classroom pedagogical approach grounded in existing learning and instruction theories and pedagogies?*

To answer this question, I conducted *integrative literature review* (Torraco, 2005). The forthcoming Chapter 2 (Literature Review) presents the results.

The second part of this research is guided by 4 practical research questions that help to test the application of the SFC approach in real-life settings and to understand its impact on the classroom participants, that is, students and instructors. The **RQ 2** and **RQ 3** are concerned with the impact of SFC, as perceived by its participants. In the context of my investigation, the *perceived impact* is defined as the *attitudes to* and *experiences of* the Self-Flipped Classroom approach. The impact is thus not measured in terms of factual outcomes or events; instead, it is described from the perspective of students and instructors. **RQ 2** focuses on the students' perception:

RQ 2: *What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

Since the SFC approach consists of two distinct phases (*creation* and *reuse* of learner-generated materials), it is logical to break the **RQ 2** into two sub-questions that focus on each of the phases separately:

RQ 2A: *What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*

RQ 2B: *What is the student acceptability and experience of learning from video materials created by other students?*

Analogously, **RQ 3** focuses on the perceived impact of SFC from the instructors' perspective by describing their attitudes and experiences. Furthermore, to make the answer to this question more informative for other instructors who might consider using SFC in their practice, **RQ 3** also has a sub-question on the specific challenges and opportunities of the new approach:

RQ 3: *What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

RQ 3A: *What opportunities and challenges do instructors face while implementing SFC into their teaching?*

In addition to defining and evaluating a new pedagogical model, this research is concerned with a broader investigation into the ways of teaching a range of 21st century skills. The thesis therefore also answers the following research question:

RQ 4: *What transferable skills and literacies does the Self-Flipped Classroom pedagogical approach help to develop?*

Finally, this thesis presents and evaluates two variants of the Self-Flipped Classroom approach, Enclosed and Distributed, and in Chapter 7 (Discussion) I compare and contrast the findings from the two case studies to answer the final research question:

RQ 5: *What are the similarities and differences of Enclosed and Distributed SFC?*

The part of this work that answers research questions **RQ 2** to **RQ 5** is practical by nature and thus it was conducted through *fieldwork* with two case studies. The first case study has an embedded design with multiple units of analysis, while the second case study is a holistic exploration of a single unit. The main approach for data collection and analysis used throughout the practical part of the research was qualitative. However, to answer **RQ 4** I also used a range of quantitative methods to complement my qualitative data. By answering all of the above research questions, I aim at drawing a comprehensive picture of the SFC both from the theoretical and practical viewpoints.

1.6 Thesis Structure

The remainder of the thesis structure is as follows:

Chapter 2 answers the **RQ 1** by discussing how existing theories and pedagogies inform various components of the proposed SFC approach. Here I also review several empirical studies that have relevance to the reuse of learner-generated materials and could be identified as premises for the Self-Flipped Classroom pedagogical approach.

In **Chapter 3**, I present the methodological approach for this research and outline my ontological and epistemological position as a researcher. This chapter justifies the approaches used to answer each of the research questions, and provides an overview of all data collection and analysis methods. Here I also provide a description of the two case studies of this research with details and specifics of the corresponding courses, student content creation methods, and used tools.

Having set the scene, the three subsequent chapters present the main results of this research. In particular, **Chapters 4** and **5** present two case studies that have been conducted across 4 years from the Fall Semester 2015 to the Spring Semester 2019, as per the duration of my PhD study. Each of the case studies comprises two parts corresponding to the two phases of the Self-Flipped Classroom approach: (i) creation of the materials by students in the process of their learning; and (ii) reuse of those materials by instructors for teaching other students. The case studies presented here represent the two variants of the Self-Flip approach: Case Study A, presented in Chapter 4, is dedicated to the Distributed Self-Flip, while Case Study B, presented in Chapter 5, is dedicated to the Enclosed Self-Flip. Chapters 4 and 5 answer the research questions **RQ 2** and **RQ 3**, along with the corresponding sub-questions.

Chapter 6 then explores how the SFC approach can facilitate the development of a range of transferable skills, thereby addressing the **RQ 4**. Most of the findings presented in this chapter can be regarded as benefits of collaborative production of multimedia learning artefacts in general; nevertheless, these findings are based on and are directly relevant to the Self-Flipped Classroom teaching and learning.

In **Chapter 7**, I summarise all of the empirical findings of this research and articulate my answer to the **RQ 2** and **RQ 3** on the overall perceived impact of the SFC. Also, I continue to answer the **RQ 4** by further discussing transferable skills acquisition, and then answer the **RQ 5** by comparing and contrasting the results of the two SFC case studies, as well as presenting considerations for the SFC approach implementation. Furthermore, this chapter presents design recommendations for technological tool support for collaborative learning through making and management of a library of student-produced materials.

The final **Chapter 8** revisits the research questions and summarises the main contributions of this work. It also describes limitations of this research and outlines future research opportunities in this area.

Chapter 2. Literature Review

This chapter starts with an overview of some fundamental educational theories that form the ground for the Self-Flipped Classroom approach. We begin with constructivism (Piaget, 1967), and review other relevant theories, pedagogies and approaches that stem from constuctivism and its variations (e.g. social-cultural constructivism (Vygotsky, 1978)). I then position SFC among them and answer the first research question of this thesis:

RQ 1: *How is the Self-Flipped Classroom pedagogical approach grounded in existing learning and instruction theories and pedagogies?*

To answer the **RQ 1**, I study various relevant pedagogical perspectives using the *integrative literature review approach* (Snyder, 2019). To clearly and succinctly express my findings, I synthesise a "map" that shows the relationships between SFC and the state of the art, thus combining existing perspectives to create a new theoretical model. The resulting visual representation of this "map" is shown in Figure 2:1.

Further on in this chapter, I review several empirical studies that can be seen as premises for the SFC approach. By relating various SFC components to prior research, and through identifying limitations of these prior studies, I lay the groundwork for hypothesising and explaining the effects of SFC. Finally, I will outline my research direction for the empirical testing of SFC that will be presented in the rest of the thesis.

2.1 Theoretical Foundations

The 20th century saw a rise in the development of *constructivist learning,* which was driving the shift from passive *objectivist learning* to the learning that is active, experiential and collaborative. *Constructivist learning theory* is defined by the Encyclopaedia of the Sciences of Learning (Seel, 2012) as a theory about how people learn. "It states that learning happens when learners construct meaning by interpreting information in the context of their own experiences" (Gogus, 2012).

Objectivist pedagogies, that were dominant before that, and are still often referred to as traditional teaching, are based on the theory of *behaviourism* (Thorndike, 1898; Watson, 1913; Pavlov, 1927; Skinner, 1957). These pedagogies advocate teacher-centred learning which relies on direct instruction and lecture-based teaching. The main idea of objectivist learning is that instructors are sole authority figures and that their knowledge can be transferred to and acquired by learners (Jonassen, 1999). In contrast, the constructivist pedagogues assert that knowledge is constructed by learners themselves, individually, and co-constructed socially based on learners' interpretations of the experiences in the world. Hence, "knowledge cannot be transmitted, instruction should consist of experiences that facilitate knowledge construction" (Jonassen, 1999, p.217).

It is particularly important to note the following difference: the objectivist learning approach posits that learners can replicate the transmitted knowledge using systematic rules and gain the same understanding as the instructor through factual learning. Therefore, such pedagogies provide poor support for the development of "creative thinking, higher-order problem solving, transferring and applying knowledge to concrete experiences" (Gogus, 2012), i.e., the lifelong learning or 21st century skills, which are considered essential by many contemporary scholars and practitioners (Trilling & Fadel, 2012). In contrast, these skills are at the centre of constructivist learning, which provides students with opportunities "for reflection and critical thinking to make sense of the world and create understanding, not just the memorising of right answers" (Brooks & Brooks., 1999).

Many modern constructivist pedagogical approaches ground themselves, at least partially, on the cognitive theory of *constructivism*. The theory developed by Jean Piaget from the early 1920s advocates that knowledge is actively constructed by a learner through the contact with the world (Piaget, 1967). It mostly focuses on individual knowledge construction, where meaning is discovered and formed into unique structures which continually evolve through the interaction with other people and with things (Ackermann, 2001). Piaget was the first to notice that children create their own explanations of the reality that are different from the explanations presented to them by adults. Thus, children construct their own knowledge and this knowledge evolves with them through different stages of their cognitive development. Piaget spent his life studying children's individual cognitive processes focusing on autonomous learning and independent thinking. As Piaget was working on that, his contemporary Lev Vygotsky developed the concept of knowledge construction further by positing that such construction is impossible without the social environment that the child is existing in. This gave birth to the *social* or *social-cultural constructivism* (Vygotsky, 1978).

The theory of *social constructivism* suggests that learning (i.e. cognitive development) is inseparable from its social context, and therefore its nature is inherently collaborative. Vygotsky posited that the development of cognitive structures and consequently knowledge construction happens through social discourse. According to Udvari-Solner (2012), a critical principle of this theory is that "knowledge or the way humans understand their experiences and reality is not simply constructed, it is co-constructed through the frameworks of language and culture in relationships among individuals".

Expanding the ideas of social constructivism further to address challenges of developmental and educational psychology, Vygotsky articulated the concept of *zone of proximal development* (Vygotsky, 1978). This concept intended to support accurate assessment of children's intellectual abilities and evaluation of effective instructional practices (Podolskiy, 2012). *Zone of proximal development* refers to the distance between the level of what a learner can do independently and the level that s/he can achieve with support from a more knowledgeable other. Vygotsky suggested that through social interaction and problem-solving with others, adults or peers, a learner is engaged in sense-making and therefore develops skills necessary for solving similar problems independently: "what the child is able to do in collaboration today he will be able to do independently tomorrow" (Vygotsky, 1987, p.211). In this work, Vygotsky set foundation for scholarship/enquiry of collaborative learning.

This brings us to the notion of *collaborative learning*, which is an umbrella term for various types of collaborative and cooperative learning that, in a nutshell, relate to *learning with others*. In the context of classroom, Dillenbourg gave a broad definition of collaborative learning as a "situation in which two or more people learn or attempt to learn something together" (Dillenbourg, 1999b). He further refined collaborative learning as a situation where learners engage in activities that are normally not possible in individual learning, such as "explanation, disagreement, mutual regulation", which in turn initiate certain cognitive processes, such as "knowledge elicitation, internalisation, reduction of cognitive load". At the same time, during collaboration, the learners still experience cognitive processes inherited in individual learning like "induction, deduction, compilation" (ibid, p.5). Therefore, creating environments and mechanisms that encourage learners to engage in activities that trigger both of these types of cognitive processes is a key guiding principle for collaborative learning proponents.

In the decades since publication and translation of Vygotsky's work to English, collaborative learning has been studied from numerous perspectives and its benefits for learners are universally recognised (e.g. Gokhale, 1995; Roschelle & Teasley, 1995; Dillenbourg, 1999a). However, collaborative settings do not necessarily guarantee that effective collaborative learning will actually occur. Consequently, educators are continuously looking for effective ways to stimulate collaboration by introducing innovative methods of teaching (e.g. Wheeler et al., 2008; Daniels & Cajander, 2010), as well as by using various technology (e.g. Hamer et al., 2011; Fu & Hwang, 2018).

The Web 2.0 era has significantly expanded the ways in which we collaborate and learn. As a result, today's collaborative learning is taking different forms and is borrowing social trends from computer-supported environments. In this research, the term "collaborative learning" is used in a broader sense than in the classic Dillenbourg's definition. Collaboration of learners in Self-Flipped Classroom occurs in three distinct forms: they collaborate (i) in pairs or small groups during artefact creation; (ii) within a larger cohort during Flipped Classroom activities and interim discussions of artefacts (possibly as part of formative peer assessment); and (iii) through sharing and the reuse of the created artefacts. The first two forms of collaborative learning (i,ii) are in line with the Dillenbourg's definition. The third form (iii), on the other hand, includes sharing and reuse of the artefacts, which is a less explicit form of collaboration where students do not even have to know with whom they collaborate or learn together. This form of collaboration has elements of *crowdsourcing*, i.e. getting value from a large group of other people (Brabham, 2013), and *participatory culture*, where consumers become producers (Jenkins et al., 2009). This form of collaboration will be discussed in more detail later in this chapter and in Chapter 6.

Importantly, all forms of collaborative learning not only facilitate the 'proximal development' by helping a learner to achieve the level of ability of another more knowledgeable peer, but also stimulate the development of essential life-long learning skills, such as communication, reflection and critical thinking (Gokhale, 1995). As such, collaborative learning is one of the key founding components of the SFC approach.

Collaborative learning is closely related to *experiential learning*, and an even more general notion of *active learning*, both of which are rooted in the scholarship of John Dewey, one of the greatest philosophers and educationists of the first half of 20th century. Although Dewey is not typically directly credited for the development of constructivism, he made important contributions to what later became constructivist learning. Dewey was one of the first to argue for the importance of life-long learning skills development, instead of mere memorisation of facts and mastering of a pre-defined set of skills, so that learners could develop their full potential and use those skills in future for greater good (Dewey, 1897). Dewey may also be considered the first advocate for active learning: back in 1916, he wrote about learning as "an active, personally conducted affair" (Dewey, 1916). Much later, in late 1980s and early 1990s, building on Dewey's philosophical work, Charles Bonwell and James Eison defined *active learning* as a pedagogical approach (Bonwell & Eison, 1991).

Bonwell and Eison (1991) define *active learning* as anything that involves learners in doing and thinking (i.e. reflecting) about what they are doing. This leads to the theory/principle of *reflective learning and practice*. As many learning theories and principles, it is rooted in earlier ideas, including those by Dewey. I would like to make emphasise on Donald Schön's particular focus on two types of *reflective practice* (Schön, 1983) that help to learn better in professional context. I translate these types of reflection to the process of SFC artefact creation:

- *Reflection-in-action* refers to reflection during an action where a change can still be applied to the action itself (Yanow & Tsoukas, 2009). In SFC, learners would reflect on knowledge acquisition (what needs to be understood and remembered) and knowledge construction (what it takes to create an artefact based on the learned content).
- *Reflection-on-action* focuses on past, finished actions where the outcome of the later reflection cannot influence the action anymore (Fessl et al., 2017). This would refer to the second phase of SFC, where learners reuse peer-produced artefacts to learn from them, and in the process of learning factual information reflect on the way the artefact was created (including quality of presented information, point of view, similarities and differences compared to one's own approach to artefact creation, etc.).

This brings us to the key theoretical principle of the constructivist learning in relation to the Self-Flip approach – the theory of *constructionism.* The notion of collaborative and peer-assisted learning does not cover the 'making' part of Self-Flipped Classroom, which is better informed by a close relative of Piaget's theory – the learning theory of *constructionism*, developed by Papert in 1987.

Seymour Papert, who was a student of Piaget, expanded on *constructivism* to describe the concept of *constructionism* in terms of helping the student, as part of their learning, to produce constructions that others can see and critique. Papert explored how learners engage in a conversation with their own or other people's physical constructions (artefacts), and how these conversations encourage self-directed learning, and as a result enable the construction of new knowledge (Ackermann, 2001). According to Papert and Harel, *constructionism* shares with *constructivism* the idea of learning as "building knowledge structures", and "adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach or a theory of the universe" (Papert & Harel, 1991, p.1).

Constructionism also differs from constructivism in terms of the emphasis on instruction. "Piaget never intended his theory of knowledge development to be a theory of learning and teaching" (Kafai, 2006a, p.35), and thus he does not prescribe any pedagogical methods, nor articulate the role of instructor in the process of learner's knowledge discovery. Papert, on the other hand, does not oppose any form of instruction and talks about changing the nature of interaction between student and teacher.

I see the following features of constructionism as particularly relevant to the SFC approach:

- *Learning through making* – creation of meaningful artefacts through or because of learning activities is at the core of both the constructionism theory and the SFC approach.
- *"Public entity"* – the constructionist artefacts are designed and created to be visible and accessible to others, which very well translates to SFC where the artefacts are used by other students for their own learning.
- *Instruction* – constructionist instruction implies interaction between the instructor and the student during the process of design, discussion and creation of learning artefacts that have social relevance, which in SFC pedagogy translates to the instructor's role of a facilitator of active learning activities, including those that result in artefact creation.
- *Technology* – an important component of constructionism is the use of technological tools for facilitation of learning processes. While technology is an inherent part of HCI and CS, the specific emphasis here is not on the technology that a learner learns to use, but the technology that a learner uses to learn, such as tools that support blended learning (e.g. Flipped Classroom), but also those that facilitate the production of artefacts.

It is worth pointing out that, although Papert's work is mostly associated with his famous Logo programming language (Logo Foundation, 2014), and constructionism in general is often closely linked with technology, Papert himself did not see technological tools as the driving force for teaching and learning. While admitting that technology is important, he advocated that "people, not computers, are the driving force for educational change" (Kafai, 2006a, p.35).

Constructionism was criticised as being just a "meta-theory" and not explicit enough in terms of how the learning occurs. Hoban *et al* (Hoban et al., 2010), for example, argued that while highlighting the importance of the interaction between personal and social influences on learning, constructionism does not help to articulate and understand the process of designing and making artefacts, and therefore does not justify why this process is valuable for learning itself. At the same time, Kafai (2006a) explains the constructionist knowledge construction process through *appropriation*. She cites Papert, arguing that physical objects play a central role in the knowledge construction process as "learners make knowledge their own and begin to identify with it" (Kafai, 2006a) when they transform that knowledge into a physical artefact.

Kafai and Resnick also suggest that the process of artefact creation could be explained through theories of design (Kafai & Resnick, 1996), which strengthens the link of this approach to HCI, where design is a key element. Another parallel could be drawn here with the models of media literacy presented in Figure 2:3, where conscious message creation with a specific audience and purpose in mind resonates with deliberate creation of an artefact for someone else to learn from it (see sub-section Media literacy 2.2.3a) below in this chapter and Section 6.1 in Chapter 6).

Constructionism is the final key theoretical principle which I would like to discuss here. The next step is to review the most relevant pedagogies and approaches and discuss their significance to SFC. These are briefly presented here but will be discussed in more detail in the next section dedicated specifically to them.

To make the navigation through complex relationships of theories and pedagogies easier for the reader, I present my visual representation of the SFC theoretical foundations in Figure 2:1 below. This figure presents my understanding of the relation of some of the key *constructivist learning theories* and *pedagogies* to the proposed Self-Flipped Classroom approach. It is not my intention to give a full account of all constructivist learning instances here. I focus only on the aspects that are of the greatest concern to the main ideas of the SFC approach, which are (i) a non-didactic mode of teaching, (ii) constructionist mode of learning (i.e. through making), and (iii) peer contribution to the learning (i.e. cocreation and reuse of learning artefacts).

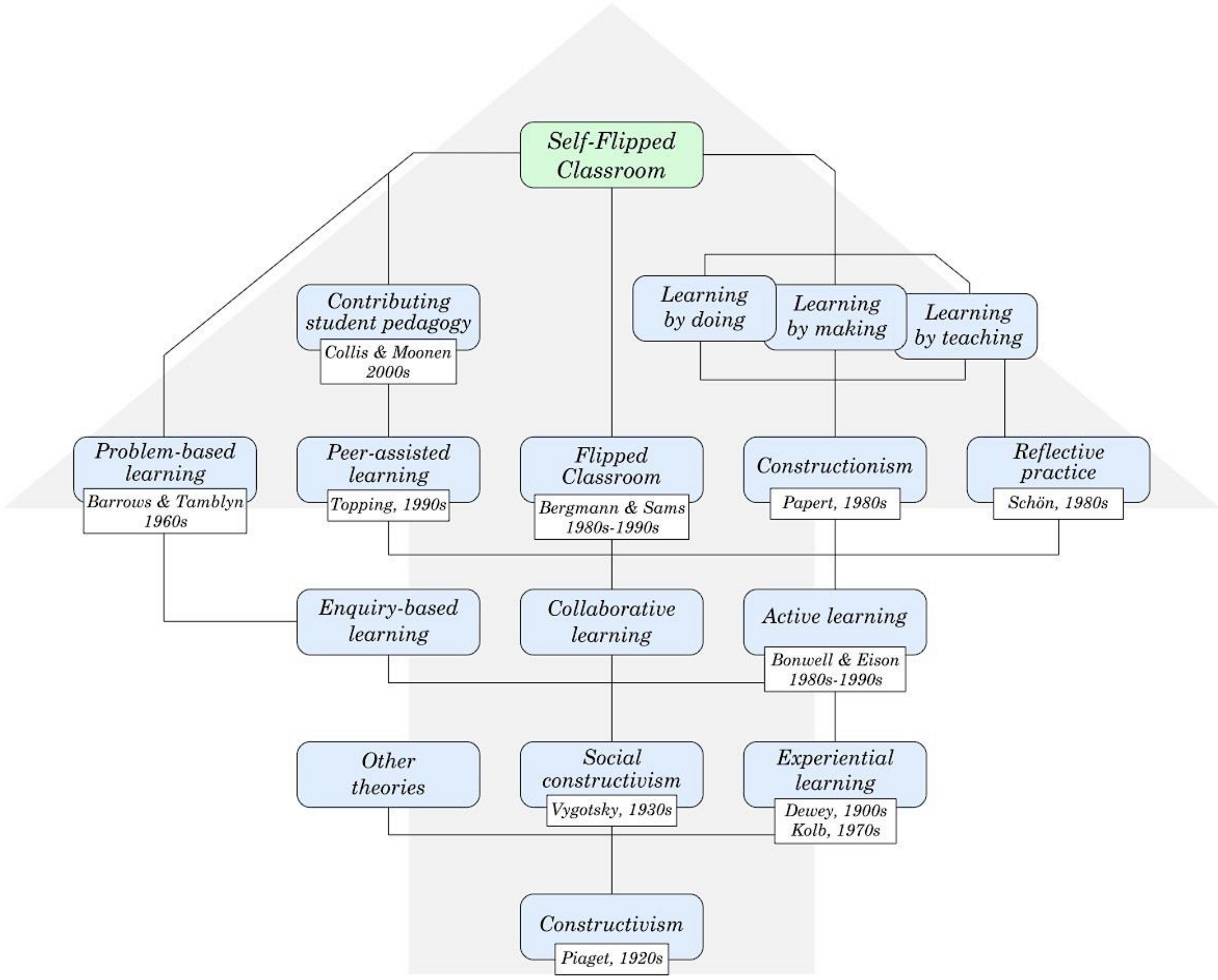

Figure 2:1. Theoretical underpinnings for Self-Flipped Classroom

Navigating though Figure 2:1, the theory of *constructionism* brings us to the trio of *learning by doing, making and teaching*. In this thesis these are also referred to as *learning* ***through*** *doing, making and teaching.* After struggling to find in my literature review a comprehensive definition that explains the distinction between *learning by doing* and *learning by making*, which is very important in the SFC context, I propose my own below.

On its own, *learning by doing,* which in literature is often synonymous to *experiential*, *active*, *enquiry-based* and *problem-based learning*, is the process of making sense of experiences where learners "actively engage in making things and exploring the world" (Bruce & Bloch, 2012). In other words, it is a variant of learning based on hands-on activities as opposed to passive memorisation of information. *Learning by making,* which is often confused with *learning by doing,* combines the essence of *learning by doing* with the ideas of *reflective* *practice* (Schön, 1983) and Papert's notion of artefact as a *public entity* (Papert & Harel, 1991) discussed above. I therefore posit that in Self-Flipped Classroom *learning by making* is the next level of *learning by doing*. More precisely, *learning by making* adds a layer of reflection to the process of knowledge construction: a learner would still need to *do* the task in question (e.g. connect a sensor to a computer and write a program for it to work) but in addition to that, the learner will also *make* a shareable artefact about this project (e.g. a video tutorial about proximity detection). Thus, learners will not only acquire the skill of programming but will also be engaged in reflective thinking about programming that they are doing, i.e. why the program is needed, what are the implications of specific decisions made in it, and finally, how to best present and explain it to someone else. The skills and knowledge can be embedded even further by going one more level up through to *learning by teaching* (Martin, 1985). I therefore argue that creation of educational resources is an ultimate level of learning (viz.: do, demonstrate, explain, teach).

Another branch of collaborative learning that is worth mentioning here is *peer-assisted learning* (Topping & Ehly, 1998), which can take many forms including *peer teaching*. Topping defined peer-assisted learning as a process where students learn by helping their fellow students to learn (Topping, 1996). Peer-assested learning makes its appearance in many modern pegagogies, as will be discussed later in relation to *contributing student pedagogy* (Collis & Moonen, 2005) and *Flipped Classroom* (Bergmann & Sams., 2012).

Contributing student pedagogy (CSP) is one of the closest approaches to SFC as illustrated in Figure 2:1. Due to its significance, this is described in greater detail in the next section, see sub-section 2.2.2b. Briefly, CSP is characterised by the following two features (Hamer et al., 2008):

- Students contribute to the learning of others by creating various instructional materials, demonstrations, worked examples, or examination questions.
- Students value the contributions of others by accepting the peers-created materials as useful and necessary in the context of the course.

This aligns well with the Self-Flip approach but does not, however, incorporate the Flipped Classroom model or the use of the content contributed by students for teaching other student cohorts (in the next iteration of the same course or in other courses), and so it cannot be considered a sole logical predecessor of the SFC.

Last but not least, the SFC's second main component is Flipped Classroom (Bergmann & Sams., 2012). It will be discussed in great detail in Section 2.2.1 below.

Of course, Figure 2:1 is just an approximation of the complex historical development and interaction of the various learning theories related to the SFC. In most of the cases, it is impossible to draw a straight chronological arrow between different theories and approaches as they evolved side by side, synthesising human history and experience. Nevertheless, this diagrammatic overview of the field should clarify the most important historical and logical relationships between the theories on which the Self-Flipped Classroom approach is built.

2.2 Modern Pedagogical Approaches as SFC premises

This section discusses several modern pedagogical approaches that are grounded in the theoretical principles discussed above. The section is divided into four subsections. The first two focus on the main foundations of the SFC approach: *Flipped Classroom* and *learning through making*. The third subsection covers the role of pedagogy in developing 21st century skills, such as media literacy, collaboration, and fair use and attribution. The final subsection reviews existing examples of reusing learner-produced materials, highlights the research gaps, and further justifies the introduction and testing of the SFC approach.

2.2.1 Flipped Classroom

Modern education is being continuously reshaped by the advances in information and communication technologies (Duderstadt et al., 2002). Following the rapid adoption of Massive Open Online Courses (MOOCs) by world's leading universities, a form of blended learning called Flipped Classroom (FC), which allows the instructor to free the in-class time from lectures and give the students an opportunity to learn more actively (Bergmann & Sams., 2012), is increasingly being applied in the context of higher education worldwide. Stanford (Coursera-partner Community, 2013), the University of Sydney (The Australian Government Office for Teaching and Learning, 2014), Edinburgh (Bates & Galloway, 2012) and York (Dodds, 2015) universities, to name but a few, recognise the following advantages of the Flipped Classroom model for STEM subjects: (i) students learn at their own pace; (ii) classroom time provides students with more opportunities for creativity; and (iii) instructors spend more time with students on authentic research (Freeman & Schiller, 2012). These and many other universities are gradually introducing the FC approach to the curriculum (Bishop & Verleger, 2013; Kerr, 2015; Abeysekera & Dawson, 2015; Zuber, 2016; White et al., 2013).

Flipped Classroom is a form of learning where course material is delivered to students in the form of audio-video recordings and reading materials via digital and online media. Students prepare for class in advance by studying these materials outside of class time at their own pace, and then they do 'homework' in class by solving problems together with the teacher and other students (Bishop & Verleger, 2013; Kerr, 2015; Abeysekera & Dawson, 2015). This approach advocates for the principle of student-centred active learning that, as known for decades, ensures "greater student involvement and knowledge retention" (Bonwell & Eison, 1991). The Flipped Classroom is a form of active learning; for greater context, below I provide an overview of the active learning pedagogy and discuss the paradigm of shifting the focus from *teaching* to *learning* by comparing different active learning approaches.

As one can see in Figure 2:2, derived from a survey of the research on Flipped Classroom by Bishop and Verleger (2013), student-centred learning (SCL) is based on active learning, which in turn includes such approaches as problem-based learning, peer-assisted learning and others. As SCL's name suggests, it places the student at the heart of the learning process. It moves the focus from the academic instructor to the student and promotes active and peer learning (Machemer & Crawford, 2007). Moreover, student-centred learning is associated with learner's self-guidance and self-direction (Attard et al., 2010). Thus, students within SCL are given options in shaping their courses and influencing the development of their study programme. Tsui (2002) in her study of critical thinking development asserts that SCL supports teaching the students 'how to think' rather than simply 'what to think'. The two main principles of SCL are changing passive acceptance of knowledge to its active discovery (problem-based learning) and promoting collaboration instead of competition between the students (peer-assisted learning).

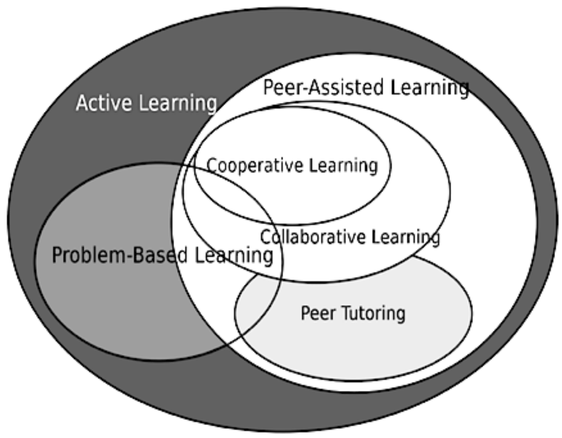

Figure 2:2. Venn diagram of several student-centred learning approaches (Bishop & Verleger, 2013)

One branch of social-constuctivism presented in Figure 2:1 that has not yet been discussed is *problem-based learning* (PBL) (Barrows & Tamblyn, 1980), which is an instance of a very broad notion of *enquiry-based learning* ('Inquiry-Based Learning', 2012). Problem-based learning is a pedagogical approach that involves students working on an open ended real-life problem and learning the subject material through finding a solution to that problem (Boud &

Feletti, 1998). Problem-based learning was praised for being more effective than traditional memory-based learning approaches to form a body of practical knowledge that a learner can use in future (Barrows & Tamblyn, 1980). Very often, problem-based learning is organised as collaborative work in small student groups, with an emphasis on developing skills and knowledge valuable in professional work (Vasiliou et al., 2013; Ioannou et al., 2016).

Topping's definition of peer-assisted learning (PAL) includes the notions of peer tutoring and peer assessment (Topping, 1996, 1998). PAL is a process where fellow students are "helping each other to learn and learning themselves by teaching" (Topping, 1996, p.322). Topping advocates advantages of the approach for Higher Education particularly because of larger class sizes in comparison to primary and secondary education, and limited resources to provide individual tutoring to every student by the instructor.

Since the late 90's, deliberate and systematic approaches to enable students to support learning of their peers were introduced in a number of UK universities (Potter & Hampton, 2009). Examples of technology-supported peer learning environments include Moodle (Oxford, Open and Newcastle Universities) (Open University, n.d.; University of Oxford, n.d.; Newcastle University, n.d.), PeerWise (universities of Edinburgh, Glasgow and Nottingham) (Casey et al., 2014; Hardy et al., 2014), and Aropä (universities of Glasgow, the West of England, and Robert Gordon University) (Purchase & Hamer, 2018a, 2018b). However, with regards to measuring the effectiveness of active learning, Prince states that it is difficult to analyse what actually works as "there is not one or two core elements that can be clearly identified with student learning outcomes" (Prince, 2004, p.229). This is particularly problematic for problem-based learning (PBL) as it may include different combinations of various components of active learning activities (see Figure 2:1). While no clear evidence demonstrates that PBL enhances student academic achievement as measured by exams (Colliver, 2000), there is still evidence to suggest that PBL provides a more challenging, motivating and enjoyable approach to education as demonstrated by Norman and Schmidt (Norman & Schmidt, 2000). Studies also suggest that "PBL develops more positive student attitudes, fosters a deeper approach to learning and helps students retain knowledge longer than traditional instruction" (Prince, 2004). Furthermore, as peer-assisted learning is supposed to provide a natural environment to encourage the development of interpersonal skills, PBL develops problem-solving and life-long learning skills (Crouch & Mazur, 2001; Prince, 2004).

As the Flipped Classroom approach is grounded on PAL and PBL, there is relatively little direct reporting on how the FC improves student learning outcomes. This is largely because it is hard to measure by conventional assessment methods such skills as creativity, critical thinking, or problem solving, which the FC students are likely to develop in addition to the required minimum of the course knowledge (Moffett & Mill, 2014).

Another criticism that the FC often receives is a significant workload on the instructors who wish to transition from the traditional lecture format (Moffett & Mill, 2014). Creation of good (as engaging as possible) pre-class material demands great time investments, especially if it is in the form of video recordings. Wagner et al (2013) who flipped an Electronic Systems Engineering module at the University of Regina (Canada), report that "on average a 15-minute online lecture required 2 to 3 hours of production and editing time using extremely user-friendly development tools". Another report from a Stanford instructor said that it took them 10 weeks to create the content for a 10-week 'Child health and nutrition' course (Coursera-partner Community, 2013). Moreover, instructors who were not familiar with the FC and multi-media content creation, were likely to require additional training and support throughout the production of the pre-class materials (Talbert, 2014). The proposed SFC approach aims to help eliminate or at least reduce the extent of some of these issues, while keeping and enhancing the learners' benefits of FC.

2.2.2 Learning through Making

Further to the definition of *learning through making* discussed in Section 2.1.1, I would like to reiterate that *learning though (or by) making* represents a higher level of knowledge construction compared to *learning by doing.* The layer of reflection added to the learning process is crucial here and it is emphasised even more when the learner is *making* an artefact suitable for teaching others, thus engaging in *peer teaching* and consequently in *learning by teaching* (Martin, 1985). The creation of educational resources rightfully places itself at the top of the learning hierarchy, as it involves the stages of doing, making, demonstrating and teaching. There is a wealth of educational research on the value of peer teaching, which includes peer tutoring and peer assessment, though learners themselves often seem to not appreciate it, thinking that it is just a way for teachers to offload their duties to the students. Below I discuss several pedagogical approaches where learners engage in creation of content that is suitable for peer teaching.

a) Student content creation

Easily available personal digital technologies nowadays offer increasing opportunities for students in schools and universities to learn through making of their own digital artefacts. Yet it has been argued that students use technology more creatively and efficiently outside of the education system than they do within classrooms (Rodriguez et al., 2012). Multiple studies proposed that schools should take into consideration learners' passion for technology and their naturally developed media literacy to enhance their learning experience. The development of Web 2.0 technologies, which are characterised as those that emphasise user-generated content along with user interaction and collaboration (Mcloughlin & Lee, 2008), power another growing trend: yesterday's *audience* increasingly become content *creators* and *communicators* (Wheeler et al., 2008) "Producing, commenting, and classifying are just as important as the more passive tasks of searching, reading, watching, and listening" (New Media Consortium, 2007, p.9). I argue that we should take advantage of this cultural shift, and actively steer education practices towards student content creation.

Asking students to create class content is not new, of course. Indeed, instructors asked students to create multiple-choice questions to build interaction and support excitement in the classroom back in 1980s (Gleason, 1986; Bonwell & Eison, 1991), long before Web 2.0. However, with an abundance of technological tools available today we see more studies demonstrating learning improvements for students who engage in content creation (Fellenz, 2004; Hardy et al., 2014; Bates et al., 2011; Casey et al., 2014; Bates et al., 2014; Rodriguez et al., 2012). In addition to multiple-choice questions, examples of student-produced content introduced into the curriculum include editable wiki-pages (Sener, 2007; Wheeler et al., 2008), narrated animations (Hoban et al., 2010), video vignettes (Read & Lancaster, 2012), digital games (Prensky, 2001; Harris et al., 2009; Kafai, 2006b), as well as video tutorials (Gravett & Gill, 2010; Engin, 2014).

In addition to linking the creation of digital products with deeper learning of the subject and improved academic performance, evidence suggests further benefits, such as: (i) multi-media production helps students to better engage with the subject and to look at the material from a different angle (Hoban et al., 2010); (ii) it stimulates the development of creativity and critical thinking skills (Mcloughlin & Lee, 2008); (iii) the produced materials become tangible objects for student learning portfolios (Mcloughlin & Lee, 2008). Finally, when tasked with creating digital products for the purpose of teaching, students are also encouraged to reflect on how best to communicate their learning to others, which further embeds their own learning (Dale, 1946). In the context of adoption of new pedagogies, such as Flipped Classroom, student content creation is particularly valuable as it allows us to shift some of the workload on the FC content creation from instructors to students.

According to Prensky (2001), today's students are "digital natives"; they were born and raised in the Internet era and expect (or at least accept) a curriculum that involves working with digital multimedia and content creation. Similarly, educators report numerous benefits of student content creation and incorporation of multimedia materials into teaching and learning activities (e.g. Lee & McLoughlin, 2007; Seely Brown & Adler, 2008; Wheeler et al., 2008).

b) Contributing Student Pedagogy

The idea of student-produced learning resources brings us to the concept of Contributing Student Pedagogy (CSP) that was first introduced by Collis and Moonen in the beginning of 2000s (Collis & Moonen, 2005). Since the introduction, this concept has been further researched and developed in several works by Hamer *et al* (Hamer et al., 2008, 2011, 2012). The principles of CSP originate from constructivist (Piaget, 1967) and socio-cultural constructivist (Vygotsky, 1978) cognitive theories, as well as the more recent theories of knowledge sharing and development through communities of practice (Cajander et al., 2012).

CSP is defined by the following two features (Hamer et al., 2008):

1) *Students contribute to the learning of others*. These contributions may take a variety of forms, such as creating tutorial materials, demonstrations, worked examples, and examination questions.
2) *Students value the contributions of others.* The students believe that the contributions of others are potentially useful in the context of the course.

The core element of CSP is the explicit creation of tangible, identifiable artefacts by one or more students for the purpose of being used by other students for their own learning. Hamer *et al* (2011) differentiate student artefacts useful for CSP from those which are not rich enough to explicitly be used by other students for learning, e.g. "the use of 'clickers' in lectures where the 'artefact' created by students is a numerical answer to a multiple choice question"; as well as those which are created solely for the instructor (as part of an assessed exercise) and are not reusable in a broader than just exemplary way (Hamer et al., 2011).

Hamer *et al* (2008) conducted a comprehensive literature survey of CSP studies with particular interest in Computer Science education. The survey resulted in several case studies with description of a range of CSP environments (working alone, in pairs, or in small groups), different types of produced artefacts (peer presentations, multiple-choice questions, essays, hand-outs, and web resources such as wikis), and their persistence (stored persistently for a long time, or alternatively, transient). In addition to fostering learning of the course contents, the survey also highlighted the CSP's role in promoting the development of a wide range of skills such as research, communication, interdependence, individual accountability, and interpersonal skills (Hamer et al., 2008).

One limitation of the CSP literature is that it most commonly reports only on the effect of CSP activities on the development of generic skills and social interaction rather than on a significant increase in the understanding of the course content. Only rare quantitative studies were found to assess whether student understanding of the content improved as a result of their contribution to CSP activity (Denny, 2013; Bates et al., 2011, 2014; Yu & Chen, 2014). Moreover, the authors admit that they found very little literature addressing the quality of student artefacts that were produced. Therefore, they argue that the course assessment needs to be aligned with the instructor's expectations of the students: "if the instructor desires high-quality student contributions (so as to ensure that these contributions are genuinely assisting the learning of other students), then the quality of these contributions must be assessed" (Hamer et al., 2008). This insight influenced the design of my case studies, where I ensured that student-produced materials undergo assessment by the teaching team in terms of their suitability for teaching other students.

2.2.3 21st Century Skills

The growing attention to Flipped Classroom and other alternatives to traditional pedagogies partially reflects the increasing concern of STEM educators about teaching "soft skills" to their students. Today, a successful graduate has to demonstrate not only solid core subject knowledge, but also a set of additional 21st century skills to be able to compete in the job market more effectively. These skills are also called transferable and life-long learning; they include, among others, communication and critical thinking, as well as information and media literacies (Trilling & Fadel, 2012). When approaching the teaching of 21st century skills, it has been argued that these skills could be "integrated into nearly any subject area" (Bergsma et al., 2007), including sciences (Goldberg et al., 2013), and should be taught across the curriculum in both secondary (Bergsma et al., 2007) and higher education (Christ, 2004). One of the research questions of this thesis, **RQ 4,** is dedicated to investigating how the proposed Self-Flipped Classroom pedagogical approach helps to develop transferable skills and literacies.

Primarily driven by the industry demands, the need for formal training in writing and speaking is now also acknowledged by most Computer Science academics. There is a history of calls for additional communications skills training in Computer Science curricula (Blume et al., 2009). Furthermore, in the Web 2.0 era, where all of us are gradually becoming both producers and consumers of content, i.e. content *prosumers* (Mcloughlin & Lee, 2008), educators need to prepare their students to be capable content creators. Creation of multimedia messages is no longer a prerogative of artists and journalists; technical professions nowadays require the ability to produce creative solutions, powerful portfolios, and video presentations, and graduates need to be equipped with these skills to compete at the job market (Blume et al., 2009). Thus for example, media literacy competency as a component of general education is particularly important for HCI students. When designing, prototyping, evaluating, and presenting technology to an end-user (using video prototypes, tutorials, supporting documentation, etc.), HCI professionals have to be proficient in creating clear multimedia messages and understanding their effect on the intended audience.

a) Media literacy

While discussing content creation and the process that learners go through when they approach, discuss, design and create artefacts, we need to explore the notion of *media literacy* as a prerequisite for the ability to create anything meaningful. In this sub-section, I therefore revisit the existing models of media literacy with a focus on the process of content creation, and then, using the existing models as a foundation, I define my own model for the use in the study of students developing their media literacy skills (see the study in Chapter 6).

Media literacy has been discussed and approached by educators in Europe, North America and Australasia for nearly three decades. Many studies, including white papers (Hobbs, 2010; Jenkins et al., 2009) and national reports (Krucsay, 1999; Thoman, 2004), were dedicated to this important component of 21st century life. It is also a component of an effective pedagogical approach, which attracts increasing attention from STEM educators in general, and HCI instructors in particular. Yet there are gaps in our understanding of media literacy, both as a research area and as an educational concept (Jolls & Wilson, 2014).

Hobbs (2016) and Bordac (2009) suggest that defining media literacy is not an easy task due to the variety of global education systems and fast changing nature of the media itself. For the purpose of this study, I started with one of the most accepted general definitions: media literacy is *"the ability of a citizen to access, analyse, and produce information for specific outcomes"* (Aufderheide, 1993, p.6). Aufderheide (1993) suggested that each component of this definition could be articulated in a number of ways. Hobbs (2010) and Churchill (2010) among others have developed their own models of media literacy. These models have commonalities, e.g.

they share the components of *analysis, evaluation* and *creation*; but they differ with respect to other factors (e.g. accessing, questioning, reflecting and acting) as well as in their structure (linear or circular). The relatively abstract nature of these models limits their utility to theoretical work, while a more practical framework was required for my empirical research. Therefore, building on the flexibility of Aufderheide's definition and drawing on other media literacy research (particularly Aufderheide, 1993; Churchill, 2010; Hobbs, 2010; Jolls & Wilson, 2014), I derived my own cyclic model of media literacy, which includes definitions of the key components: *access, analyse, produce* – see Figure 2:3.

This model largely echoes the Hobbs's scheme and preserves the *creation* component which in fact is almost always present in such models. As Gilmor reasons, "being literate in today's world means more than just smarter consumption, however actively you do that. Being literate

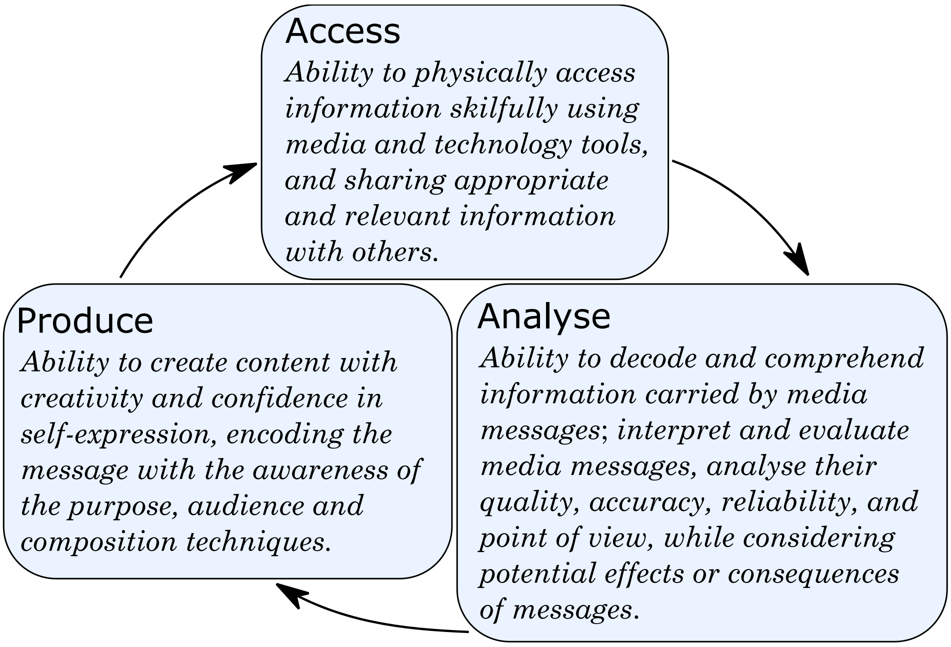

Figure 2:3. Media literacy model

is also about creating, contributing and collaborating" (Gillmor, 2010, p.60). This perspective resonates with the theory of constructionism (Papert, 1986), discussed in Section 2.1.1, with a particular emphasis on that the best learning happens through application of the knowledge in the form of learning artefact creation (Papert & Harel, 1991; Hoban et al., 2010). I will use and subsequently update this model when evaluating the impact of the proposed approach on the development of media literacy skills as part of collaborative creation of learning materials, see Chapter 6, Section 6.1.

b) Fair use and attribution in collaborative content creation

One of the first items on the agenda of a newly hired computer science professional (e.g. an Interaction Designer or Software Engineer) is learning how to effectively collaborate and co-create within the team. One of the first items on the agenda of a university undergraduate CS student is learning about plagiarism and the appropriate use of quotations and references in academic writing. Effective and fair collaboration is key to modern large-scale engineering, but it is not easy to teach it in a university (Soundarajan et al., 2015), where students are often discouraged from reusing text or code created by other students.

Digital media has broken down barriers to communication and collaboration, leading to the emergence and development of the *participatory culture* where people are "shaping, sharing, reframing, and remixing media content" instead of consuming pre-constructed messages, and "they are doing so, not as isolated individuals, but within larger communities and networks", as argued by Jenkins (2013, p.2). So, to stay competitive in this new world, today's university graduates must be well equipped with *soft skills*, such as communication, collaboration and digital literacies, on top of the solid core subject knowledge.

Modern education re-evaluates and re-designs university curricula to help students acquire necessary skills and competencies to be "full, active, creative, and ethical participants" in the participatory culture (Jenkins et al., 2009), and a growing body of research indicates that, see e.g. (Laurillard, 2009; Pifarré & Kleine Staarman, 2011). Collaborative learning with the use of social technology is one of the solutions. It has been shown to be effective for improving learning outcomes, and enabling peer-learning and community building (Schroeder et al., 2010; Waycott et al., 2013). However, it can also lead to blurring the boundaries between acceptable (and/or encouraged) collaboration and academic misconduct (Pickard, 2006; Simon & Sheard, 2015). Similarly, the issues of copyright infringement in online content creators and "remixers" communities are attracting interest of both computer supported collaborative work (CSCW) and computer supported collaborative learning (CSCL) researchers, e.g. (Fiesler & Bruckman, 2014; Fiesler et al., 2016; Faklaris & Hook, 2017).

One of the contributions of this thesis that addresses these issues is a study of student collaboration and attribution patterns where students actively co-created and shared learning artefacts, see Chapter 6, Section 6.2.

2.2.4 Reuse of Learner-Produced Materials

As part of my literature survey, I found several examples of incorporation of student content creation into teaching, some in the context of the Flipped Classroom approach. These examples naturally link many of the themes discussed in this section so far. They inspired me to study and generalise the idea of reusing student-produced materials into a new pedagogical approach, and I therefore present them below as an acknowledgement of prior art.

First, Hoban *et al* (Hoban, Macdonald, & Ferry, 2009; Hoban, Macdonald, Ferry, et al., 2009; Hoban et al., 2010) present a notion of "slowmation" (abbreviated from "Slow Animation"), which is a simplified form of stop-motion animation that encourages students to design a multimodal representation of their learning and integrates features of clay animation, object animation and digital story-telling. The experiment was conducted at the University of Wollongong, Australia, where students of preservice teacher education were tasked to create explanatory resources on given science topics in the form of narrated animations. The final artefacts were published on a website with a purpose to be shared among other students. A subsequent qualitative study showed that the students developed a deep understanding of the science content as a result of both producing and then consuming the resulting artefacts (Hoban, Macdonald, Ferry, et al., 2009; Hoban, Macdonald, & Ferry, 2009).

The second example of reusing student-produced materials is from Lund University, Sweden, by Granmo & Bengtsson (Granmo & Bengtsson, 2015). It was a cross-faculty project at the medical faculty where journalism students filmed short videos on specific anatomic themes for medical students. The content of the videos was planned, script-written and presented to the journalism students by *senior medical students* from higher years of study. The created content was used as teaching material in Flipped Classrooms and *junior medical students* received access to the videos to continuously rehearse and repeat the material over time. At the same time, the journalism students practiced their camera technique, directing and editing, and even learned some anatomy in the process. This study focused on the consumer side of the reuse of the materials and through a mix of a quantitative and qualitative evaluation concluded that the experiment was a success for junior medical students. Such multi-layer cross-faculty collaboration between students while creating educational content was truly inspiring for me.

Another example of a large-scale collaborative project reusing student-produced materials was carried out in the field of education and fine art (Miño-Puigcercós et al., 2019), where students from 5 undergraduate degree programmes produced various audio-visual materials to be shared openly with other learners through a digital platform. This study was based on the implementation of a big European project called DIYLab (Do It Yourself in Education: Expanding Digital Competence to Foster Student Agency and Collaborative Learning) (Sánchez-Valero et al., 2017) at the University of Barcelona (Primary Education, Early Childhood Education, Social Education, Education and Fine Art). The main focus of the study was to incorporate learning approaches related to the Do It Yourself (DIY) culture that fosters "creativity, collaboration, self-regulation, authorship and a critical use of digital technology". During the project, 471 students of the University of Barcelona collaboratively created and shared 76 audio-visual artefacts about their learning and the processes that contributed to it. The researchers then carried out observations, recordings, field notes and discussion groups with the students in order to investigate how the innovation had transformed teaching and learning practices, and the roles of teachers and students. Among other findings, the authors of the study concluded that in the prosumerism settings, the students were forced to be out of their comfort zone of passive learners – they had to think and behave differently, which was challenging for many students. The authors furthermore highlighted that one of the other main challenges of using student-produced materials as part of curriculum was that the instructors were no longer in control of the results: it was hard for them to predict the outcome of student creations, which inevitably impacted the teaching and learning process.

Finally, one of the most SFC-relevant examples was presented in a paper from Zayed University, United Arab Emirates by Marion Engin (2014), which described a project where students of second language course were tasked to create a video tutorial on aspects of academic writing, which would then form a part of the already established Flipped Classroom model. These video tutorials aimed to be products of student research on such topics as paraphrasing, summarising, writing a thesis statement, and intended to leverage their interest and experience of technology and multimodal environments. The instructor was hoping to achieve a better learning both for the students-producers, who conducted research and created the videos, and for the students-consumers, who were not motivated to engage with videos made by the instructor. In the outset of the course, the instructor prepared a set of ten videos to serve as examples to help the students get accustomed to the concept of video tutorials. A qualitative analysis of student reflection and feedback, collected via a questionnaire and follow-up interviews, revealed several benefits for students-producers, such as (i) improved subject learning through researching a topic, looking for sources, assessing the information and deciding what is relevant for the video tutorial; (ii) students' engagement in higher level thinking and learning processes when they were preparing a concise summary of the topic to fit into the video (which is in line with what I was discussing earlier regarding the learning though making of teaching materials); (iii) moreover, students' awareness of the fact that their video would be used for other students' learning, was a driving force for their particular attention to content and language accuracy and further improved their subject learning.

In contrast to the benefits for students-producers, the consuming side of the learning did not benefit as much as was hoped. The author reports tension between students-producers and students-consumers with regards to valuing student-produced materials and learning from them. The students felt uncomfortable when learning from peer-produced video tutorials as they lacked confidence in their content and presentation style. Interestingly, it seems that the same driving forces that stimulated better learning in the producing part of the process were the reasons why the consuming part of the process did not go well. In particular, the author of the study mentioned the fear of giving misinformation in the video tutorial as the main reason why students focused on accuracy of the presented information and correctness of used language for explanations. However, the same fear seemed to be interfering with the acceptance of peer-produced materials as trustworthy. The students did not trust their peers' knowledge and were concerned that the videos might contain misinformation. This led to Engin's conclusion that while students clearly benefited from playing the role of content producers, their experience and learning in the role of consumers was less positive.

This study provides many insights for the SFC context, however, it also has limitations. As a small-scale case study, it is hardly generalisable, especially to other educational contexts, such as STEM subject learning. The specifics of the studied context in terms of education (second language learning, linguistics, from Arabic to English), and culture (the Middle East), make the results' generalisability and transferability rather weak. In particular, it was very difficult to demonstrate the correctness of created teaching materials about English language to students for whom English was not a native language. Contrast this, for example, with a tutorial on programming an LED to blink: a student-consumer can check its correctness simply by following it and seeing it if works. Furthermore, the authors of the study do not report on any other aspects of perception of students-consumers apart from the distrust of peer-produced videos. Therefore, I believe it is worth to continue this line of research to further investigate how students evaluate peer-produced videos, how they compare their own videos to those created by others, and what they do to check if there is any misinformation in the videos. The acceptance of peer-produced materials as suitable for use in teaching and learning is a complex issue, and I hypothesise that even distrust can be used as a tool to stimulate higher levels of learning.

All studies presented above share some common findings and observations, which are valuable for identifying a new pedagogical approach at the intersection of Flipped Classroom and student-produced learning materials. However, these studies have three important limitations: (i) none of them evaluated the process of creation and reuse of the student-produced materials from the perspectives of both the instructors and the students; (ii) the studies were conducted by the teaching teams themselves, i.e. not by an independent researcher that would have been less biased and less emotionally involved; and (iii) the studies were far removed from STEM education, and therefore the results were not directly applicable in the context of this thesis.

Despite the limitations, these examples were enlightening and contained useful initial data. Thinking about replicating some of the achieved results prompted me to study the literature on evaluating and reusing student-produced artefacts, as reported in the sub-sections below.

a) Assessing and evaluating student artefacts

Perhaps the most controversial and difficult aspect of learning through making as part of contributing student pedagogy and similar approaches (including SFC) is the formal assessment of student-produced artefacts by instructors and, even more so, their evaluation by other students.

Firstly, the instructors have to ensure that the artefacts are of high quality, free from misconceptions, and are accessible for other students. Hamer et al (Hamer et al., 2008) call for the development of appropriate assessment methods for quality control of produced artefacts. Secondly, the instructors have to build an *environment of trust* where all students will value the contributions of others, especially if they passed the instructor's quality control check. Falkner and Falkner (2012) suggest that in successful CSP, students have to not only skilfully assess and value the contributions of their peers, but must also develop the required skills to evaluate their own contributions for "their potential to encourage learning by other students", which would motivate the students to create artefacts with significant value for others.

As already mentioned, my review of CSP literature did not reveal any studies that address the quality of student-produced video artefacts. Similarly, advocates of the Flipped Classroom approach urge to develop alternative assessment methods in order to measure and benefit from all of the FC advantages (Moffett & Mill, 2014).

A rare study where student-produced materials are critically assessed and evaluated was found in a paper by Bates *et al.* (Bates et al., 2014), where they study the quality of student-produced multiple-choice questions. The results of the study showed that the student-produced questions were of high quality: “More than three quarters of questions fall into categories beyond simple recall; similarly, the quality of student-authored explanations for questions is also high, with approximately 60% of all explanations classified as being of high or outstanding quality.” Overall, 75% of questions met the set quality criteria. These questions “are clear, correct, require more than simple factual recall to answer, and possess a correct solution and plausible distractors. In particular, a substantial fraction of the questions constitutes true problems (as opposed to simple exercises)” (Bates et al., 2014). Therefore, Bates *et al* conclude that with a right scaffolding, students are able to produce high quality learning artefacts that are beneficial for other learners.

Although the issue of *trustworthiness* is a recurring theme throughout the literature on CSP, so far, no evaluation of it appears to have been published. Interestingly, while Hoban (2009) and Engin (2014), among others, warn about the danger of scientific misconceptions in the student-produced artefacts, and the lack of trust from other students, Granmo & Bengtsson (2015) argue that the trust in student-produced materials can be built via a continuous student-instructor dialogue, and that the resulting materials can be more consumer (i.e. peer) oriented. I found no studies where the quality of the student-produced artefacts was evaluated by an external expert.

b) Learner-produced materials suitable for reuse

By studying the literature on empirical evaluation of integrating student content creation into curriculum, I identified a set of different types of artefacts that students can produce as part of their learning and which can be reused by the instructor as teaching materials for other students. Below I briefly list all of the identified types of artefacts. See Appendix A for a more detailed table of types of student-produced materials with descriptions, examples, supplementary resources, and references.

- **Video tutorial**: most commonly, a ‘how-to’ video that shows and explains steps necessary to solve a problem or to produce a particular result (Guo et al., 2014; Gravett & Gill, 2010; Engin, 2014).
- **Video presentation**: an instructional video that presents results of a research project done by a student or a group of students (Levick, 2014; Kearney & Schuck, 2006; Frydenberg, 2008).
- **Multiple-choice question**: a question based on the course material (pre-class reading or lectures) with several plausible answers (Hardy et al., 2014; Bates et al., 2011; Casey et al., 2014; Fellenz, 2004; Bonwell & Eison, 1991; Gleason, 1986).

- **Problem solving activity**: a problem to be investigated, discussed and analysed, which could take the form of a puzzle, a scenario, a story, a dilemma or a case study (Wiggins et al., 2016; Barrett et al., 2011; Colliver, 2000; Norman & Schmidt, 2000; Prince, 2004).
- **Blog post**: a short reflective essay about activities exercised during a teaching session and addressed to the student's peers (Costa & Kallick, 2008; Wheeler et al., 2008; Yew et al., 2007; Boulos et al., 2006).
- **Animation**: similar to a video tutorial or a presentation but created in the form of digital graphic or stop-motion (Hoban et al., 2010; Hoban, Macdonald, Ferry, et al., 2009; Stelzer et al., 2010; Hoban, Macdonald, & Ferry, 2009).
- **Podcast**: an audio recording which can be played back on a computer or a portable player. Podcasts originally were only in the audio format, however, today they often include both audio and visual format, e.g. screencasts (Salmon & Edirisingha, 2008; Seery, 2012; McGarr, 2009; Frydenberg, 2008).
- **Editable wiki-page**: a web page that enables learners to collaborate, share ideas, and curate content by editing a document together (Wheeler et al., 2008; New Media Consortium, 2007; Coursera-partner Community, 2013; Sener, 2007).
- **Vignette**: a short interactive summary of video lectures (screencasts/recaps) covering the critical concepts of the topic (Read & Lancaster, 2012; Lancaster, n.d., 2014, 2011).
- **Digital game**: a PC or mobile game that aims to introduce course content in an entertaining manner, where in order to win the game the learner needs to master certain skills (Kafai, 2006b; Harris et al., 2009; Prensky, 2001).

There are several observations that can be made about the tools that support creation and sharing of these types of artefacts. Today, all of them are primarily *digital* to facilitate their convenient creation, storage and sharing. Sharing is typically arranged *online* using such platforms as YouTube for videos and animations; custom websites created for a course delivery that have file posting and sharing features, such as discussion forums and blogging platforms, special-purpose applications such as PeerWise (https://peerwise.cs.auckland.ac.nz) that were developed to support students in creation, sharing, evaluation and discussion of multiple-choice questions; and, of course, Virtual Learning Environments, such as Moodle, Blackboard, Canvas and others, that aim at safe and secure delivery and sharing of all course related materials. Increasingly, these tools are *collaborative*, with such examples as Wiki-pages for text or static multimedia creation, and Bootlegger[1] for video creation. Instructors often seek the tools that do not require specific knowledge or skills to use, and are either *already known* to most students (e.g. smartphone camera for video creation), or are *open-source and very easy to learn*. Of course, as technology marches forward, new tools appear every day; as one of the contributions of this thesis, I will produce a set of design requirements that such tools need to meet in order to be effective in the educational context.

2.3 Chapter Summary

The first part of this chapter presented my answer to the first research question of this thesis:

RQ 1: *How is the Self-Flipped Classroom pedagogical approach grounded in existing learning and instruction theories and pedagogies?*

Since the question is theoretical in nature, its investigation was done purely by literature review. The results of this work are summarised in Figure 2:1, which presents a visual map that positions SFC in the space of existing theories and approaches.

The second part of this chapter was dedicated to a review of recent and most relevant empirical studies that I identified as premises for the SFC approach.

By relating various SFC components to prior research and identifying limitations of prior studies, I laid the groundwork for hypothesising and explaining the effects of SFC, and uncovered promising research directions for the empirical studies that will be presented in the rest of the thesis.

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[1]Bootlegger (https://bootlegger.tv/) was developed in Newcastle University to facilitate collaborative video production. More information about this tool is provided in Chapter 4 when I describe how this tool was used in Case Study A.

Chapter 3. Methodology

This chapter presents the overall research approach for this work, and outlines the methodology used throughout. It introduces the structure of the research, which consisted of a number of phases, provides justification for the choice of the research methods used, and explains what each of them involved when placed in the context of this work. Further details that are specific to the case studies are provided later in the corresponding chapters. In particular, the description of the research participants sample, the choice of questions asked in the interviews, and details of quantitative video analysis will be provided as part of the description of the context of each of the case studies.

Due to the nature of this work, I adopt research approaches that are relevant to both the fields of Education and HCI. In fact, Education and HCI share many research methods because the objectives for research in both of the fields often include understanding of human participants, exploring their behaviour in a certain context and/or their experiences of a certain innovation. Such research objectives in HCI are intended to provide a basis for the design or improvement of a *technological solution*. Similarly, such research objectives in Education are intended to provide a basis for the design or improvement in *educational settings*. This work is positioned on the intersection of the two fields, where *technological solutions are applied in educational settings*, and therefore share these objectives, which is reflected in the research approach.

3.1 Research Approach

Throughout this work, I have sought to explore what could be a new pedagogical approach to help address challenges of education. After conducting the literature review and identifying a promising research direction, I focused my investigation on how collaborative content creation, principles of prosumption, and the Flipped Classroom pedagogical model could be effectively employed to add value for students and instructors. To do so, I developed a new pedagogical approach and investigated its application in authentic educational settings. Therefore, the first part of this work – the conceptual foundation and development of the Self-Flipped Classroom approach – is theoretical, and the first research question is answered through conducting *integrative literature review* (Torraco, 2005). The second part of the work was practical, aiming to develop an in-depth understanding of the experiences of students and instructors engaged in the SFC approach. Therefore, the rest of the research questions are answered through conducting *fieldwork*, that is, studying the participants in their real-world settings (Hobbs & Wright, 2006).

3.2 First Research Question and Literature Review

The nature of the **RQ 1** (*How is the Self-Flipped Classroom pedagogical approach grounded in existing learning and instruction theories and pedagogies?*) required me to study various existing pedagogical perspectives, which were deemed relevant to the topic of my work in one way or another, and see how they could be synthesised into a "research map" where the SFC could be positioned so as to explain its relationship to the state of the art. For this task, the *integrative literature review approach* was chosen over the systematic and semi-systematic literature review approaches, due to its better fit to the context of creative collection of data for the purpose of combining different existing perspectives to build new theoretical models (Snyder, 2019).

Torraco defines the integrative literature review as "a form of research that reviews, critiques, and synthesises representative literature on a topic in an integrative way such that new framework and perspectives on the topic are generated" (Torraco, 2005). This approach thus perfectly fit my aim of creating a framework to illustrate the overall foundation of the SFC and to ground its specific elements, such as the mode of delivery, learning processes, and learning outcomes, on the existing theories and pedagogies.

Having stated a clear purpose to review the most fundamental theories and approaches that have influenced the SFC, I used a deductive approach for the search and selection of the reviewed literature. I started with the theory of *Constructionism* (Papert, 1986) which I have identified as the grounding theory for the SFC in the early stages of my work and then I moved both backwards and forwards along the education research timeline to identify the works that influenced Constructionism as well as those that were influenced by it.

Consequently, I identified work on major theories, paradigms, pedagogies, and approaches that were significant to the SFC and discussed them, looking into the connections and dependencies between each of them and classifying them into categories that were most relevant to specific SFC elements. As a result of this approach, the organisation of the literature review is not chronological but *relational* (American Psychological Association, 2001), i.e. it is arranged by relating the reviewed work to specific SFC concepts. Webster and Watson refer to this as *concept-centric structuring* of the review (Webster & Watson, 2002). I have thence identified the concepts of (i) *learning process organisation*, (ii) *tangible outcome of the learning process*, and (iii) *level of learner's interaction with others (peers)* as the most important for the SFC formation as a pedagogical approach. I discussed literature relevant to these concepts, noting however, that many theories and pedagogies would typically relate to more than one concept. The result of this work is presented in Chapter 2, Section 2.1.1.

3.3 Research Questions 2-5 and Fieldwork

While the first research question is focused on the theoretical grounding of the Self-Flipped Classroom, the rest of my research questions are concerned with the practical application of the SFC and investigation of its effect on students and instructors.

In this section I motivate and describe the fieldwork that was done in order to answer my research questions 2, 3, 4 and 5:

RQ 2: *What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

RQ 3: *What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

RQ 4: *What transferable skills and literacies does the SFC help to develop?*

RQ 5: *What are the similarities and differences of Enclosed and Distributed SFC?*

The answers to these questions first involved an exploration of students' attitude towards (i) non-traditional methods of teaching and learning through collaborative creation of multimedia instructional materials, and (ii) the Flipped Classroom based study using the teaching materials produced by other students. This was followed by an investigation of these students' experiences of the SFC pedagogical approach to determine the additional skills and literacies that they had developed as part of it. At the same time, I investigated the instructors' perspective on utilising the SFC approach in their practice, finding out which problems it helped to solve and which practical challenges were encountered in the process. Finally, I compared and contrasted the *Enclosed* and *Distributed* variants of the SFC approach to show their benefits and limitations. These research aims required the examination and description of several complex phenomena across multiple parts of my data set. My RQs therefore calls for a descriptive and analytical answer, and the most appropriate research approach for this part of the study is *qualitative inquiry* (Miles & Huberman, 1994).

Qualitative inquiry is a particularly suitable approach for me because it is also aligned with my epistemological position. I identify myself as an *Interpretivist*, in that I believe that reality is subjective to an individual's point of view and that it needs to be interpreted through research (Bryman, 2016). Further, my ontological stance is *Critical Realist*, in that I believe there is no single reality or truth, and "a pre-social reality exists but we can only ever partially know it" (Braun & Clarke, 2013), meaning that my research and interpretations will always be partial and subjective, though I will try to validate them whenever possible.

None of the existing research approaches is flawless, and the qualitative approach may be critiqued for being partial and subjective. Nevertheless, it is a solid and most suitable research approach in social sciences. The "*human*" aspect (the one that relates to the understanding of human participants) in both of the fields of Education and HCI has a large overlap with social sciences; the qualitative research approach is therefore standard in these fields and is widely considered to be the most appropriate for research questions on human perception such as **RQ 2** and **RQ 3**. It is worth noting, however, that in a few instances I mixed the qualitative approach with some quantitative methods, which will be discussed later.

All of the fieldwork studies for this research were approved by the ethics committee of Newcastle University. Furthermore, in line with the Data Protection Act (UK Legislation, 2018), all collected data and consequently the findings (including the quotes and excerpts from student artefacts) in each case study were anonymised to protect the identity of the participants.

3.3.1 Qualitative Research Approach

Qualitative research can be seen both as a paradigm for approaching research and as a set of techniques to conduct it. A paradigm in science is a specific set of values, beliefs, theories and postulates that are shared by a certain scientific community (Kuhn, 1962). A paradigm provides an overarching agenda and structure for research. Qualitative techniques are a set of particular approaches to *data collection* (e.g. observation, interview, focus group) and *data analysis* (e.g. Grounded Theory, Discourse Analysis, Thematic Analysis) (Braun & Clarke, 2013).

Generally speaking, qualitative research operates with words as data, in contrast to quantitative research which operates with numbers. The objective of qualitative research is to understand and interpret 'local meanings' in recognisable contexts, while quantitative research aims to generalise the findings to a wider population by finding relationships between different variables, explaining and predicting them (Tolich & Davidson, 2003; Braun & Clarke, 2013). Quantitative data is collected from many participants and generates a broad but 'shallow' (that is, without a complex account of each participant) representation of the studied population. On the other hand, qualitative data, which might seem 'narrow' (that is, collected from a small number of participants) is considered to be a "source of well-grounded, rich description and explanations of processes in identifiable local contexts" (Miles & Huberman, 1994).

The qualitative approach in research on understanding participants' experiences is very much in line with the classic HCI approach of experience-centred design. Experience-centred design (Wright & McCarthy, 2010) is a qualitative research approach featuring in-depth investigation of experiences as a primary resource for design. This approach affords a methodology, as well as research practice, that support gaining an understanding of lived experiences and establishment of empathic communication with the research participants. In a similar manner, my research aimed at gaining a rich understanding of the lived experiences of students and instructors who engaged in the SFC, in order to provide resources for the design of further improved educational settings using (or based on) the SFC.

The adopted qualitative research paradigm provides descriptive and analytical answers to the the research questions of this work. The general qualitative research methods used here were mixed with *ethnographic* (to provide richer description of the context) and *quantitative* (to focus on quantifiable issues that could not be explored through direct contact with participants) methods. I do not claim to have employed the *mixed method* research approach, since I merely supplemented my qualitative findings with some useful quantitative techniques. See further details in the descriptions of the case studies in Chapters 4, 5 and 6.

3.3.2 Case Study Design

The fieldwork for this research was conducted across two *case studies*. According to one of the most cited methodology authors Robert K. Yin (2006), the case study research approach has a cogent strength (compared to other methods) in its ability to examine a case in depth from multiple perspectives and within its real-life context. Case study in general is quite similar to ethnography as it involves studying participants in their natural context and making sense of their behaviour and experience. As the purpose of this work was to investigate the impact of the SFC from various perspectives (specifically: students, instructors, qualities of the created artefacts, and different course designs) and in real-life educational settings (regular university courses), the case study method emerged as the most suitable choice for the design of this research. Furthermore, Yin states that the case study method is now regarded as one of the most viable methods for doing education research (Yin, 2006). The Yin's statement is supported by numerous publications on educational case study research, including Computer Science Education studies, e.g. (Levy, 2001; Rajala et al., 2008; Štuikys, 2015; Trætteberg et al., 2016), HCI Education studies, e.g. (Cunningham & Jones, 2005; Day & Foley, 2006; Zaharias et al., 2012; Vasiliou et al., 2013), and more general educational technology research in HCI, e.g. (Traxler & Wishart, 2011; White et al., 2013; Mann et al., 2016; Kavanagh et al., 2016).

In the following sections I describe the contexts of each of my case studies, outline what methodology was used for collection and analysis of the data, and how results of the data analysis answered the research questions of this work. See Chapters 4, 5 and 6 for further details on particular research methods used for data collection and analysis.

3.3.3 Case Study A

The first case study of this research, Case Study A, was designed as an *embedded case study* (Scholz & Tietje, 2002). It comprised multiple units of analysis (specifically, the two phases of the tested approach, with the first phase iterated three times), and utilised both qualitative and quantitative research methods. The embedded case study design is considered to be a good fit for investigating complex issues because having multiple methods and several individually explored units of analysis can yield a clearer overall picture (Rowley, 2002). It was naturally most suitable for Case Study A, which was dedicated to studying the distributed variant of SFC, where the two phases of the Self-Flip approach, *artifact creation* and *artefact reuse*, take place in two different groups of students and each of the phases can happen more than once:

i. Phase I: *Artefact creation* was carried out during three consecutive instances of a final 3rd-year undergraduate module called "Ubiquitous Computing" (see Appendix B.1 for the course outline) in the School of Computing at Newcastle University. The students of this module created teaching materials as part of their coursework (mainly in the form of short video tutorials for working with Raspberry Pi kits).
ii. Phase II: *Artefact reuse* occurred at the "Physical Computing" project in the School of Engineering at Newcastle University (see Appendix C.1 for the outline of the Physical Computing project). A mix of undergraduate and postgraduate students participated in a series of extra-curriculum workshops where they used the student-produced materials

from Phase I in order to learn programming skills and apply them for solving larger problems, for example, developing prototyping technology on the basis of a bionic arm.

a) Phase I (Ubiquitous Computing)

Phase I of the Case Study A was based on the course “Ubiquitous computing” at the School of Computing, Newcastle University (see Appendix B.1 for the course outline). I was a teaching assistant (TA) on this course over three consecutive academic years: 2015/2016 (Iteration 1), 2016/2017 (Iteration 2) and 2017/2018 (Iteration 3). This gave me an opportunity to explore aspects of collaborative student artefact creation from various perspectives.

The Ubiquitous Computing (or simply "Ubicomp") course covered a part of the Human-Computer Interaction field which “is a concept in software engineering and computer science where computing is made to appear anytime and everywhere” (Weiser, 1991). The learning objectives of the course were to provide the students with a theoretical and practical understanding of advanced topics in ubiquitous computing. See Chapter 4, Section 4.2.1 for further details on theoretical and practical parts of the course as well as a description of learning activities and assessment methods.

In all three iterations, the course was offered in the Flipped Classroom format, which allowed me to explore the instructors’ experiences of teaching it as a premise for their motivation to use the SFC approach. In all iterations, the students had 70% of the final course mark assigned to the creation of multimedia artefacts, such as video tutorials and blog posts. This allowed me to observe and study the processes of student content creation as part of their regular learning, which constituted a large part of my answer to the **RQ 2A** (*What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*).

To answer **RQ 3** (*What are the instructors’ attitudes to and experiences of the Self-Flipped teaching and learning methods?*), I investigated instructor experience of preparing and running a Flipped Classroom course through *semi-structured interviews* (Braun & Clarke, 2013) with the teaching team, which covered the “attitude” part of the question. See Chapter 4, Section 4.2.2 for further details about the teaching team members and their contribution to the course, as well as further details on the data processing. The interview questions and the study ethics documents can be found in Appendix B. From this data, it was possible to analyse the instructors’ motivation for reusing student-produced content within the Flipped Classroom pedagogy.

For **RQ 2A**, I investigated the students' acceptability of the learning processes based on the collaborative learning through making of video tutorials (Iteration 1 and Iteration 2) and blog posts (Iteration 2). The research method used here was *qualitative semi-structured interviews* (Braun & Clarke, 2013), which allowed me to study the students' personal thoughts, beliefs and attitudes. The interviews were designed as open-ended to facilitate the participants' reflection on the process of artefact creation. Building on the interviews, it was possible to develop rich descriptions of the participants' experiences, and consider some implications for the SFC approach. I provide more details on the specific interview questions and data analysis procedure in Chapter 4. Furthermore, Section 3.4.1 in this chapter provides a description of interview as a research method and a justification for selecting it for this research.

The video making activities during Ubicomp were facilitated with a collaborative video production tool, called Bootlegger (Bartindale et al., 2016). Bootlegger is an open source platform providing both web and mobile components for commissioning the creation of videos. It was designed in Open Lab, Newcastle University with the purpose to support non-professionals in generating high production value content in situated locations such as concerts, marathons, and ethnography fieldwork. Bootlegger users employ their mobile phones to capture short video clips, the framing and description of which are defined and requested by the producer/facilitator of a particular project; Bootlegger can further be used to develop a final video for the event, without the need for an expensive video production setup. Bootlegger has previously been successfully used in a variety of scenarios, including education (Bartindale et al., 2016; Sarangapani et al., 2016). The "openness" of the app and my ability to directly collaborate with its developers permitted me to collect data which is usually hard to obtain (such as system logs) to study the student behaviour in the collaborative environment of this tool. This was crucial for this research as it allowed for the investigation of students' co-creation of their artefacts from an "objective" perspective (in contract to the "subjective" perspective, which is explored through talking to the students). Analysis of the metadata helped me to answer **RQ 4:** *What transferable skills and literacies does the SFC help to develop?* I used several statistical analysis methods, which are explained in detail within the context in Chapter 6. Also, see Section 3.4.2 at the end of this chapter for a descriptive summary of all statistical methods used.

In addition to the numerical and textual Bootlegger metadata I also qualitatively analysed student video artefacts from Ubicomp Iteration 1. These consisted of a sample of the 10% of most popular clips used in student final videos (50 clips, with 6 to 18 uses each) and all 102 student final tutorials submitted for the assessment, along with the marking criteria. These were analysed using the *inductive thematic analysis* (Braun & Clarke, 2006) where I looked for both common and distinctive themes and patterns in the videos.

Additionally, preliminary analysis of quantitative data and the student artefacts in Iteration 1 led to a number of questions that warranted further investigation. A questionnaire was created to focus on collaborative behaviour choices made by the students during the process of using Bootlegger for their video creation. This questionnaire comprised 6 closed- and 2 open-ended questions that were tested and distributed to the students electronically. Further details can be found in Chapter 6, Section 6.2.2.

In addition to the video artefact analysis conducted in Iteration 1 of the Case Study A, I also analysed the student text artefacts (forum discussions and blog posts) in Iteration 2 and compared the students' collaborative behaviour during their work with videos and with texts. Specifically, I studied: (i) similarities between materials created by different students; (ii) remixing of ideas that were articulated by different authors in the discussion forum and in the individual students' blog posts; (iii) the use of other media (text, music, pictures, etc. not produced in the class); (iv) similarities between the submitted artefacts and shared materials (clips and forum discussions); and (v) attribution patterns (referencing the original authors of the video clips, ideas and examples that appeared on the discussion forum). All of the above contributed to answering the **RQ 4**, i.e. the development of the transferable skills and literacies by the SFC approach. See Section 3.4.1 in this chapter for an outline and justification of the used content analysis techniques, and Chapter 6 for a more detailed description of the methods and techniques.

In the 2017/2018 academic year (Iteration 3), more data was collected and analysed with the **RQ 2A** in mind. In particular, once again I investigated the students' experience of and the attitude to collaborative creation of teaching materials (video tutorials and blog posts) as part of the students' own learning. This time however, to increase the response rate and simplify the data processing, an online survey questionnaire was conducted at the end of the semester where students were asked 11 Likert scale and multiple-choice questions and 1 open-ended question. 17 Ubicomp students out of 48 filled in the questionnaire. In addition, that year, aiming to improve generalisability of the study as well as strengthening the results obtained from the interviews thus far, I probed attitudes towards the SFC ideas among a wider student population. For this, a similar questionnaire with questions related to learning from watching videos and creation of sharable artefacts was distributed among all students studying STEM subjects at Newcastle University. 121 students participated in this survey. Section 3.4.2 in this chapter presents questionnaire as a research instrument, Appendix B contains the survey questions, and Chapter 4 presents further details about the data processing.

b) Phase II (Physical Computing)

The second phase of the Self-Flip approach was implemented within the scope of the "Physical Computing" project in the Case Study A, which was conducted as an inter-disciplinary and inter-departmental project in the School of Engineering at Newcastle University, aiming at developing a Physical Computing Toolbox for Engineering and Science Students in Higher Education. More details on the project are presented in Chapter 4 and in Appendix C.1.

As part of the project activities, two workshops entitled "Python for Raspberry Pi – Sensors and Motion Control" were organised, which were open for all students in Newcastle University who wanted to learn how to use Raspberry Pi with various sensors and motion control tools. The workshop participants learned how to code using the programming language Python (Python Software Foundation, n.d.) and used the Raspberry Pi General Purpose Input Output (GPIO) (The Raspberry Pi Foundation, n.d.) interface to build customised prototypes. See Appendix C.1 for the Project briefs, which were used as handouts for the workshop participants.

A selection of video tutorials created by the Ubicomp students in the Phase I was provided to the workshop participants in the Flipped Classroom mode (prior to the workshops). This allowed them to study basic skills of working with Python and Raspberry Pi before coming to the workshops. The time at the workshop was then fully devoted to applying the acquired skills in practical activities (such as building a prototype of a bionic hand).

In total, 29 participants took part for the first workshop (more then 150 applied, 35 were confirmed with a place), and 20 participants took part in the second workshop (only 2 of them did not attend the previous one).

The data collection for this phase included the following.

With a focus on **RQ 2**: *What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

- Voluntary pre-workshop surveys with 18 students, asking them to self-report existing level of programming skills and confidence, as well as their motivation for participating in the workshop.

- Voluntary post-workshop surveys with 18 students, exploring their experience at the workshop, their perceived improvement in understanding and implementation of computing concepts, as well as their opinions on the use of student generated videos.
- An hour-long focus-group with 9 volunteers from the workshop students, discussing the student experience of learning from the video tutorials produced by other students.

With a focus on **RQ 3**: *What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

- A 40-minute *semi-structured interview* with the workshop instructor, aimed at understanding their experience of teaching in the Flipped Classroom format using student-produced materials.

I also recorded student activity in the online YouTube channel which was used to deliver the instructional videos for the students' preparation for the workshops. This allowed me to see how many participants actually visited the channel and which videos they watched.

See Chapter 4, Section 4.3 and Appendix C.3 for more details.

Table 3:1 below presents an overview of the data collection methods employed across both phases and iterations of the Case Study A.

Table 3:1. Data collection methods employed in the Case Study A

Data collection method	**Phase I**			**Phase II**
	Iteration 1	Iteration 2	Iteration 3	
Classroom observation	+	+	+	+
Instructor interview	+			+
Student interview	+	+		
Student survey	+		+	+
Focus group				+
Artefact analysis	+	+		
Bootlegger metadata	+	+		
Blog posts and forum data		+		
Video view data				+

3.3.4 Case Study B

Case Study B, due to the nature of its context (specifically, a newly developed course, to which I had access only once), was designed as a *holistic case study* (Scholz & Tietje, 2002), that is, it was conducted within one course and one cohort of students using only qualitative data analysis. This design was well suited for an investigation of the enclosed variant of SFC where the students took up two roles: the *creators* of the multimedia teaching resources, as well as their *re-users*. Below I describe the two phases of the SFC together.

a) *Phase I and II (Complex IT systems in large organisations)*

In the spring semester of the year 2017/2018, I conducted a study at Uppsala University in Sweden, with the aim to investigate how the Self-Flip approach could be applied to the same group of students within the same course.

The studied course was called "Complex IT systems in large organisations". The learning objectives of the course were to introduce students to the development, procurement, implementation and maintenance processes in complex IT systems in various organisations. The readings of the course included a popular novel on software engineering problems and scientific papers in the area. The assessment comprised a group project and an individual exam. The group project involved the creation of multimedia artefacts, specifically a video and a text report. These were shared among the students and used as a basis for a discussion on some of the key learning goals in the course. The students needed to learn from what their classmates presented in their videos and text reports in order to pass the final exam, which constituted an application of the Self-Flipped approach. See Chapter 5 for further details on this course, the course syllabus could be found in Appendix D.1.

The total number of students taking the "Complex IT systems in large organisations" course was 47. The main data collection for the this part of the study was *semi-structured interviews with open-ended questions* (Braun & Clarke, 2013). With the help from the course instructors, I was able to recruit a self-selected yet representative (in terms of demographics) sample of the cohort, which included 10 male and 2 female, 9 Swedish and 3 international students. The interview questions were focused on the students' experiences of both phases of SFC: the creation of the artefacts (**RQ 2A**) and the learning from peer-produced artefacts (**RQ 2B**). See further details in Chapter 5, Section 5.3, Appendix D.3 for the interview schedule with the questions, and Appendix D.2 for ethics documentation used in this study.

The course was taught by a course leader and an assistant instructor. Both of them agreed to be interviewed about their experiences of teaching a Self-Flipped course. Data collection and analysis were done with the **RQ 3** (investigating instructors' attitudes and experiences) and **RQ 3A** (investigating opportunities and challenges of SFC) in mind, see Appendix D.3 for the interview questions. The data from the interviews was processed using *inductive thematic analysis* (Thomas, 2006); see further details in Section 3.5 of this chapter below.

3.4 Methods for Data Collection and Analysis

This section provides an overview of all methods used for data collection and analysis in this research.

3.4.1 Qualitative Data

Observations

Participant observation is a data collection method that implies the researcher to be "present at, involved in, and recording the routing daily activities with people in the field setting" (Schensul et al., 1999). The observation in Case Study A, as in all ethnographic research, was the starting point in my data collection and served two purposes:

i) To provide a comprehensive understanding (also referred as cultural experience) of the course settings and dynamics of the study participants. This was essential for further planning and organisation of the research and for data collection (to make sure that the participants and I were speaking 'the same language').

ii) My role as the TA and unobtrusive observer helped the students get used to me (this could be referred to as an "endorsement of the presence in the community"), which was useful for later data collection (more relaxed interviews, more volunteers for survey participation).

Overall, I used participant observation as a meta method and did not generate any actual data, apart from *running descriptions* (Sangasubana, 2011) of the settings and events that constituted the context of Case Study A. This helped me to design and operationalise all the other methods of data collection in this case study. Moreover, it helped me as a researcher to "get inside the skin" of most of the participants, as the more time was spent with them the better it was for understanding of the actual situation, which had a direct impact on data analysis. However, I also acknowledge the fact that knowing the participants well can lead to empathy and potential personal bias in data collection and analysis, which is common for all ethnographic research that aims to see things from the point of view of the participants (Randall et al., 2007).

Interview

The biggest portion of the data in both of the case studies was collected by directly talking to participants, through interviews and a focus group. As the primary purpose of this research was to investigate the perceived impact of the new pedagogical approach based on students' and instructors' experience, the qualitative interview was chosen as the principal method of data collection. According to Braun and Clarke (2013), qualitative interviews are ideally suited for the types of research purposes that are focused on understanding perceptions and experiences.

Interview is a research method where the researcher meets the participant (originally face-to-face, but now also often virtually, via telephone or video call) and engages them in a spoken conversation which is guided by series of prepared open-ended questions. These conversations are typically audio-recorded and later transcribed to facilitate the work with the data as written text (Bryman, 2016).

Semi-structured face-to-face interviews are the most common type of interviews in qualitative research (Braun & Clarke, 2013). The following factors, outlined by Braun and Clarke (ibid.) as the main strengths of this type of data collection, determined the choice of the method for this research: (i) possibility to generate rich and detailed data on personal experiences and perspectives of the participants; (ii) flexibility of the process where the researcher can explore unplanned topics and directions; (iii) adequate data can be generated from small samples; (iv) control over the data produced by the participants, so that the researcher may increase the likelihood of gathering of useful data. All of these factors were essential for the success of the current research.

A few limitations of the method had to be considered too, such as (i) researcher's time required to organise, conduct and transcribe the interviews; (ii) participant's time and motivation to take part in the interviews; (iii) limited breadth of topic coverage due to the smaller sample sizes of research participants; (iv) lack of anonymity and weak fitness for discussion of sensitive issues. In this research, these factors were mitigated by carefully planning lead researcher's time for organisation and transcription of the interviews, as well as collaborating with another Open Lab researcher. That researcher helped to collect and transcribe several interviews as part of the data collection in the first phase of Case Study A (she then used those interviews and some other parts of that case study data for her own research purposes). Another mitigation was an offer of small monetary payments, such as pre-paid shopping vouchers, to the student interview participants as an incentive and compensation for their time commitment. This helped to improve the numbers of recruited interviewees. The limited breadth of data from qualitative interviews is an acknowledged limitation of all qualitative research methods, however the depth of the collected data, as well as particular suitability of this method for the main research purpose of this work, outweigh this limitation. The lack of anonymity was judged as not critical for this data collection because (i) the topics planned to be discussed in the interviews were not of particular sensitive nature, (ii) all course instructors were willing to participate in the first place, and (iii) all student interviews took place after the students knew their final course marks, so that their participation could not have any impact on their course outcome.

Focus Group

The focus group method is another powerful qualitative research method which is a form of group interview where data is collected simultaneously from multiple participants (Bryman, 2016). An important distinction between focus groups and individual interviews is the emphasis on interaction between participants during the focus group discussion. As with individual qualitative interviews, Bryman (2016) highlights the suitability of focus groups to investigate participants' personal experiences, attituded and perceptions. However, according to Braun and Clarke, focus group participants do not necessarily have to have a personal stake in the investigated topic (Braun & Clarke, 2013). Therefore, this method was ideally placed for collecting data in the second phase of the Case Study A, where I explored students' attitudes and experiences of learning from peer-produced videos. I could not guarantee that all workshop participants would watch instructional videos prior to the workshop activities and would therefore be able to give a full interview about it. Yet, bringing together several students, with at least some of them hopefully having experience of learning from those videos, was seen as the best way to explore the workshop participants' acceptability and perception of learning from peer-produced materials.

The focus group method has many strengths similar to the individual semi-structured interviews, such as flexibility and possibility of multi-angled exploration of studied topics. In addition to that, focus groups are good for facilitation of interactions between participants that result in meaning-making (Braun & Clarke, 2013). On the other hand, the disadvantages of focus groups are: (i) difficulty of in-depth probing any individual views or experiences; (ii) difficulty of ensuring an effective discussion; (iii) more challenging logistically to organise. These issues were mitigated by the fact that the focus group discussion was supplemented with the autogenerated real-time results from the questionnaire which the participants filled in immediately before the focus group. Having those results allowed me to engage the participants in the conversation about the use of peer-produced learning materials and having students with different levels of Flipped Classroom experience was helpful for the dialog. With regards to the logistics, asking students to stay for the focus group after the workshops has worked for the first planned session (when the workshops were accompanied with hot drinks and refreshments) and failed for the second planned session (when there were no refreshments and the students rushed away in order to get some food, which was understandable given that the workshop lasted for a whole afternoon).

Inductive Thematic Analysis

The principal approach for analysis of qualitative data in this research project was *inductive thematic analysis* (Braun & Clarke, 2006). It was used for analysing the collected qualitative data from the interviews and the focus groups because it allowed for an open minded, bottom up approach to the identification of themes and patterns of meanings throughout the data set in the context of the posed research questions. The purpose of this part of the investigation was to "allow research findings to emerge from the frequent, dominant, or significant themes inherent in raw data, without the restraints imposed by structured methodologies" (Thomas, 2006). Regarded as one of the most commonly used qualitative methods of data analysis, thematic analysis involves studying the data by purposefully identifying recurring topics that are coded to form particular themes and provide ground for answering the research questions.

All interviews were transcribed. I did most of the transcribing myself in order to further familiarise myself with the data. Then, I looked for the common themes, or *codes*, emerging from the interviews. For example, in the instructor interviews from Case Study A, the participants mentioned the time they spent to prepare for the FC and the additional effort it took to create the video materials; the corresponding discussions were grouped into a theme "workload". Similarly, in the student interviews from Case Study B, the participants mentioned how they enjoyed the video-making, how much they learned from the process, and how they perceived the workload of the video-making; these topics were grouped into a theme of perceived "worth" of video-making by students.

In order to increase the credibility of my coding process, I performed checks of *inter-coder reliability* while doing analysis of the interviews and the focus group data. For each part of the data analysis I initially coded only a small part of the data sample (e.g. one or two interviews, or two to three video tutorials). I then shared a sample of data with a second researcher (my supervisor, the course instructor, or another PhD student from the Open Lab) who read and coded a sample of data comprising usually about 10% of the whole corresponding data set. Then we reviewed our coding and calculated the intercoder reliability, i.e. the degree of agreement among the two coders, using the SPSS statistics platform to find the Cohen's Kappa coefficient. According to Landis and Koch's recommendations (Landis & Koch, 1977) for interpreting Cohen Kappa values, values from 0.0 to 0.2 indicate slight agreement, 0.21 to 0.40 indicate fair agreement, 0.41 to 0.60 indicate moderate agreement, 0.61 to 0.80 indicate substantial agreement, and 0.81 to 1.0 indicate almost perfect or perfect agreement.

Also, for the Case Study A, I performed *member checking* with some participants who were available for contact (at least three students at different points in time, as well as all the instructors who were involved in the case studies). Also referred to as *stakeholder checks*, *informant feedback*, or *respondent validation* in qualitative research, member checks is a practice which helps researchers to enhance the accuracy and credibility of a study by allowing the participants to assess and comment on the research findings (Thomas, 2006). This technique first became useful in Case Study A: when analysing the Bootlegger metadata and drawing conclusions from it, the student participants confirmed or explained to me some of their behaviours. I later used the technique again, when working on the interpretation of the interview data, in particular in Case Study B, for which I did not have direct observation data and therefore had to rely on the information provided by the course instructors.

In this work, I mostly relied on qualitative methods of data collection when the research questions required understanding of the participants' attitudes and experiences (**RQ 2** and **RQ 3**). I used a quantitatively-heavy mixed methods approach for the **RQ 4**, where I wanted to understand the students' behaviour and see how their skills and knowledge had developed though the learning process by using specific tools and techniques. The metadata collected through the tools used (Bootlegger, online discussion forums, YouTube – all of these will be presented and discussed in detail in the subsequent chapters focusing on particular studies) allowed me to perform statistical analysis of student behaviour which led to the formation of questions that were then posed to the students in order to extend my understanding of the studied processes and results by bringing the students' perspective in.

Drawing on Braun and Clarke's approach (Braun & Clarke, 2019), I strived to be reflexive in my data analysis. Thus, I acknowledge that my own understanding of the world and my personal experiences of the issues that I investigate (education, content creation, etc.) may influence my judgement when analysing data and making conclusions.

Qualitative Content Analysis

In order to explore students' experiences of the multi-media content creation and reuse more "objectively", I applied qualitative content analysis for student artefacts in Phase I of Case Study A, and in Case Study B. In both cases I analysed student videos. In the Case Study A, I used a sample of the 10% most popular pre-production clips used in student final videos and all 102 student final videos submitted for the assessment, along with the marking criteria from Ubicomp Iteration 1. This was used to investigate how students approached the collaborative video creation and what contributed to their media literacy skills development. In Case Study B, I analysed all final student videos to explore their main technical and stylistic characteristics in order to see how these influenced students' experience of learning from these videos. The results of both analyses complemented or were complemented by the data from the collected corresponding interviews.

The qualitative content analysis is in fact very similar to the *inductive thematic analysis* outlined above (Braun & Clarke, 2006), in that the data, which could consist of text, images, video, music or any mix types of media, is systematically examined by coding and identifying common and distinctive themes and patterns (Mayring, 2000; Hsieh & Shannon, 2005).

One important feature of content analysis of artefacts originally created for other than research purposes (in contrast to the analysis of the participant provided data, such as interview or survey responses), is that it is an *unobtrusive method* (Webb et al., 1966; Bryman, 2016). This means that the content is created without the participant's direct knowledge of the research and is therefore more natural or objective. In contrast, when participants do actively provide data to the researcher (e.g. by responding to questions or being knowingly observed), they may alter their behaviour or say things that would change their actions' view in the eyes of the researcher, and hence impact the validity of the research. In this research, content analysis of students' artefacts was extremely useful for triangulating students' responses about their experiences, and for better understanding of the outcomes of creation and reuse of those artefacts.

3.4.2 Quantitative Data

Online questionnaires

In Case Study A, I used *self-administered online questionnaires* to complement the qualitative data collected through interviews in the first phase, and to inform the focus group discussion in the second phase. A questionnaire is a research instrument consisting of a set of closed- and open-ended questions, as well as other prompts, designed to collect data from participants by asking them to complete the form themselves (Bryman, 2016). Questionnaires can be administered via *hard copy surveys* asking participants to hand-write their responses and return the forms by hand or post; via *email surveys* by sending a list of questions to the participants asking them to return the forms either by emailing the back or by printing and handing over to the researcher; via *online surveys* where a specialist software is used to publish, distribute and collect the responses and the participants are given a link to that online survey. In this research, I opted for the third option and used the Google Form service (Google LLC, n.d.), which is a free tool allowing for easy creation and distribution of personalised online surveys. The service has various question templates that help to better organise and present the questionnaires to participants; it also generates a short web link which is easy to share with participants; moreover, the service helps researchers to summarise and visualise data in real time, and collate all the collected data making it ready to transfer to other tools for further analysis if necessary.

Questionnaires in general are effective instruments to collect more data in less time than interviews or focus group and are more often used for statistical analysis of the responses. However, the use of mixture of closed- and open-ended questions could be a good addition to qualitative research (Braun & Clarke, 2013). The following advantages of online questionnaires over interviews and focus groups determined the choice of the method in this research: (i) quick and easy distribution; (ii) quick data collection and automatic generation of real time response information/summaries; (iii) highest level of anonymity; (iv) possibility to collect data from geographically dispersed participants; (v) all collected data is collated automatically with no need for transcription or further organisation. These features allowed me to collect answers from significantly more students in the first phase of Case Study A and allowed for a very quick survey of the workshop participants informing and supplementing the discussion of the focus group in the second phase of Case Study A.

Quantitative data analysis with R

Quantitative data analysis can be automated by a variety of tools, including spreadsheets such as Excel (Microsoft, n.d.), specialist software packages such as SPSS Statistics (SPSS Inc., n.d.), general-purpose programming languages such as Python (Python Software Foundation, n.d.), and special-purpose programming languages/environments for data analysis such as R (The R Foundation, n.d.).

While all of the above could in principle be used in this research, I chose R for the following reasons. Compared to Excel, R data analysis programs are separate from actual data sets, which makes it easier to avoid accidental disclosure or contamination of data (e.g. by accidental edits), as well as allows for usage of standard tools for program development, test and review. Compared to Python, R comes with a rich built-in collection of statistical analysis and data visualisation functions, which I used, for example, to produce publication-quality plots. R also provides functionality for import and export of data sets in common formats, such as CSV ("comma-separated values"), which allowed for direct processing of Bootlegger metadata, as will be discussed in detail in Chapter 6. Finally, compared to SPSS Statistics, R software environment is free for everyone to use and is less hardware resource demanding than the SPSS package.

Statistical data analysis

For the quantitative parts of the data analysis I used basic statistical analysis (Pagano, 2009). The *means, variances,* and the *95% confidence intervals* were determined for the students' pre- and post- workshop surveys results in Phase II of the Case Study A. For the analysis of data extracted from Bootlegger, I used R to determine *correlations* between different variables and extract interesting trends by calculating *frequency distributions* (Ihaka & Gentleman, 2012).

The analysis of data from Iteration 3 of Case Study A, which consisted of survey responses to close-ended questions, was exploratory rather than testing a pre-formulated hypothesis. Therefore, descriptive statistical methods were used to simply illustrate the students' attitudes to the non-traditional teaching and learning methods. For example, I used frequency distribution analysis to explore STEM students' preferences to the delivery of teaching materials: traditional lecture, watching a video, or doing a practical exercise. At the same time, I used central tendency and variability measures to explore how students would feel about creating teaching materials for learning of other students.

3.5 Chapter Summary

This chapter presented: (i) a general overview of my methodological approach for conducting this research, (ii) an outline of the research methods and tools used to answer my research questions, and (iii) a description of the two case studies. In the following Chapters 4 and 5, I will present two variants of the Self-Flip Classroom that correspond to each of these case studies, providing further details on each particular method of data collection and analysis.

Chapter 4. Distributed Self-Flip (Case Study A)

This chapter presents Case Study A. The fieldwork of this study was designed to investigate a variant of the Self-Flipped Classroom approach where the phases of *creation* and *reuse* are distributed in time and between two or more groups of participants. This SFC variant will be further referred to as the Distributed Self-Flip (or DSF). In a typical DSF, one student cohort creates SFC artefacts (e.g. in the first semester) and then later (e.g. in the second semester) another student cohort makes use of some of the created artefacts in their learning.

Initially, through collaboration with the lead course instructor, the plan for Case Study A was to design the most desirable SFC by setting up a continuous cycle of creation and reuse of student artefacts. The Iteration 1 of the Ubiquitous Computing course was meant as a pilot study, to test the collaborative content creation tools and see whether the students are able to create materials suitable for reuse. After the Iteration 2, having accumulated enough high-quality materials for reuse, the plan was to redesign the coursework so that it would fit into the cycle of continuous remake, where each year the students create new materials suitable for use in teaching next year. However, due to the change of the lead course instructor in 2017, this plan could not be realised. Instead, the Iteration 3 of the Ubiquitous Computing course preserved the same coursework as in the Iteration 2, and none of the previously created student artefacts were reused by the students of this cohort (except few being shown as coursework examples). To work around this change of plan, the distribution aspect of the Self-Flip learning was investigated by reusing the artefacts from the Ubicomp course for other students as described below.

The work on the Case Study A progressed over 4 consecutive years (from 2015 to 2019) and comprised three iterations of the first phase, the *creation*, and one iteration of the second phase, the *reuse*. As a whole, the study evolved into a cross-disciplinary collaboration between two departments at Newcastle University (UK): the School of Computing and the School of Engineering. More specifically, undergraduate Computing students created sets of instructional video materials as part of their learning on Ubiquitous Computing course, and then these materials were reused to teach programming skills to Engineering students in the Flipped Classroom format.

The findings of this chapter have been published in two peer reviewed papers, which focus on each of the two DSF phases separately: Phase I – creation: *"Video Coursework: Opportunity and Challenge for HCI Education"*, co-authored with Adriana Wilde, Stephen Snow, Madeline

Balaam, and Marie Devlin (Vasilchenko, Wilde, et al., 2018); and Phase II – reuse: *"Engaging Science and Engineering Students in Computing Education through Learner-Created Videos and Physical Computing Tools"*, co-authored with Megan Venn-Wycherley, Mathew Dyson, and Fernando Russo-Abegão (Vasilchenko, Venn-Wycherley, et al., 2020).

4.1 Introduction

There are two underlying themes, or modes, in Case Study A that directly emerged from the Self-Flipped Classroom approach idea. They can be identified as: (i) the *mode of teaching*, that is, the delivery of main teaching materials through videos, which comes from the *Flipped Classroom* part of SFC, and (ii) the *mode of learning*, that is, the learning through making and artefact creation, which comes from the *Self* part of SFC. In this case study, I first investigate the instructor and student attitudes to and experiences of the classic Flipped Classroom, with the aim of getting a practical understanding of how certain benefits of FC could be preserved while certain challenges of FC could be addressed with the help of SFC. Secondly, I investigate student learning through making and artefact creation, looking at student attitudes and experiences in general and in particular on how this way of learning helps them to acquire life-long learning skills. These two parts of the investigation are carried out in Phase I. In the third part of the investigation, which is carried out in Phase II, I explore how the instructor and student attitudes to and experiences of Flipped Classroom change with the use of student produced videos as main teaching materials of a course. All of the above research is done with the goal to answer **RQ 2, RQ 3** and **RQ 4** of this thesis.

As has already been mentioned, HCI stands out within Computer Science due to its multidisciplinarity and flexible boundaries. The combination of theoretical and technical knowledge, along with design, psychology, health, security, and other domain specific knowledge, makes teaching and learning HCI particularly challenging. Therefore, HCI educators are continuously looking for the most effective pedagogical approaches to prepare well trained professionals who can balance computing or programming abilities with others, such as design (Williams & Sears, 1998, 2000), and develop various life-long learning skills for problem-solving, critical thinking, creativity, digital literacies, as well as effective team-working (Sears et al., 1997; Trilling & Fadel, 2012). An example of such pedagogical approach was employed in the first phase of this case study, where HCI students were taught in the Flipped Classroom format and created non-traditional coursework, mastering such abilities as design, prototyping, communication, team-work, and various digital literacies along with the ability to programme Ubiquitous Computing devices.

Looking more broadly at STEM education, it is widely recognised that programming abilities are vital not only for Computer Science students but also for professional and scientific development of students in many other STEM subjects. These subjects largely use traditional, didactic approaches to teach programming, which leads many non-CS students to frustration when learning to code (Allan & Kolesar, 1996). This is particularly noticeable when it becomes necessary to express concrete ideas of a problem domain using the abstract and logic language of algorithms and then encoding these ideas via a specific programming language syntax (ibid.). This problem had also been recognised at Newcastle University, where the current practices were mainly based on traditional theoretical and academic teaching, and many students in Engineering degrees (e.g. Chemical and Electrical Engineering) were perceived as failing to engage with coding (Russo Abegão, 2017). Students found it too hard to learn programming and often mentioned in their feedback that they did not think there were enough activities on learning how to use computer programming to solve maths and design problems in non-computing modules. This issue became a motivation for a group of academics from the School of Engineering to initiate an intervention aiming to better engage their students in Physical Computing projects and thereby improve their motivation to learn how to code.

Physical computing (Przybylla & Romeike, 2014) has been shown to be an effective and affordable tool to teach computing to students of all ages. It allows for algorithm structures to be easily visualised and interacted with in the physical world (e.g. through lights, sounds, moving parts, and sensors), thereby reducing learning barriers, increasing motivation, engagement, and reasoning skills, as well as widening students' adoption of coding (Sentance et al., 2017; Przybylla et al., 2017). Thus, physical computing was ideally positioned to help address the problem in the School of Engineering, and became the centre piece of the project, called "Development of a Physical Computing HE Toolbox for Engineering and Science Students" (Russo Abegão, 2017). The aim of this project was to develop physical computing tools to teach programming to engineering and science undergraduate students, as well as to introduce postgraduate students to the application of a simple and affordable technology for making use of sensors and controllers in their research projects in the lab.

Physical computing deeply aligns with the constructionist theory, pioneered by Papert (1986) and was developed to extend the constructivist learning by adding *physicality* to the knowledge construction. Students learn computing by programming physical devices and thereby creating tangible artefacts. Further enhanced by the SFC ideas, the *physical computing artefacts* built in the first phase of this Case Study were accompanied by video tutorials for their creation, that is, *digital artefacts*, which made the physical artefacts easier to reproduce, share and preserve.

Consequently, physical computing became the link that naturally joined the two phases of the DSF in Case Study A.

This chapter has three main parts: (i) Phase I (presentation of the context, research methods and results); (ii) same for Phase II, and (iii) a discussion of the overall results with the goal to answer **RQ 2**, **RQ 3** and **RQ 4** that collectively investigate the perceived impact of the Distributed Self-Flipped Classroom pedagogical approach on university level education.

4.2 Phase I: Creation

The first phase of Case Study A comprised three iterations of creating SFC artefacts. These iterations were mutually independent in the sense that there was no artefact reuse from one to another. The main purpose of this work was to gain practical experience in SFC and to explore various aspects of the creation phase of the Distributed SFC, specifically: (i) student attitudes to the flipped classroom learning; (ii) student attitudes to learning through making, i.e. artefact creation; (iii) student experiences of collaborative artefact creation with a technological support; and (iv) instructor experiences of preparing and running a Flipped Classroom course as well as supporting student learning through making. While Phase I was not directly concerned with the artefact reuse, the teaching team always kept the subsequent second phase in mind, directing students towards creating artefacts suitable for future reuse.

4.2.1 Study Context

Phase I took place during three iterations of the Ubiquitous Computing ("Ubicomp") course during the academic years 2015/2016, 2016/2017 and 2017/2018, respectively. The Ubicomp course is one of a series of HCI courses led by Open Lab, an HCI research group at Newcastle University. At the time of the study, the course was offered to the final (third) year undergraduate students and was delivered in a Flipped Classroom format. The main learning objective of the course was to provide the students with a theoretical and practical understanding of advanced topics in Ubiquitous computing. These topics included: (i) the principles of design and evaluation of computing technology embedded into the everyday environment, such as wearable and tangible technologies, interactive surfaces, and natural user interfaces; and (ii) the issues of ethics, privacy and accessibility in ubiquitous computing. See the module outline form for a more detailed description in Appendix B.1. Some of the intended *knowledge outcomes* of the course were: (i) the ability to describe key characteristics of ubiquitous computing technologies and interfaces, including their specification, design, implementation and evaluation; and (ii) the ability to explain the issues of privacy and ethics in the context of ubiquitous computing and relate these issues to specific design and deployment decisions. The intended *skill outcomes* of the course included: (i) the ability to apply theories and concepts of ubiquitous computing and human-computer interaction to the design of ubiquitous computing technologies; (ii) the ability to design and prototype, as well as clearly document the design and build process of ubiquitous computing interfaces and interactions using off-the-shelf prototyping components. Therefore, the practical part of the course was developed around designing and prototyping ubiquitous computing technologies using off-the-shelf prototyping components, such as Raspberry Pi toolkits (The Raspberry Pi Foundation, n.d.). Raspberry Pi is a small and inexpensive single board computer designed for learning programming; its functionality was enhanced by the use of Grove Pi – a plug and play system of connectors for Raspberry Pi board, and a wide range of sensors, such as sound and light sensors, ultrasonic ranger (i.e. a distance measurement module), rotary angle sensor, LCD RGB Backlight, etc. Keeping in mind the physical computing theme that connects Phase I and Phase II of Case Study A, it is worth noting that Raspberry Pi is one of the most popular and most studied toolkits for physical computing projects (Psycharis et al., 2018).

As part of the course's summative assessment, the students were tasked to use a mobile video production tool Bootlegger (mentioned previously in Chapter 3, Section 3.3.3 and also described in more detail in the next sub-section) to collaboratively document their practical sessions. Then, by editing the created footage, the students needed to create three instructional videos explaining how to work with Raspberry Pi and the Grove Pi kits in different scenarios, for example, how to process digital and analogue data, and how to build bigger systems from smaller components by connecting their inputs and outputs. This part of the coursework weighed 30% of the student total mark for the course. See Figure 4:1 for a few screenshots from one of the produced video tutorials. The full video as well as other selected examples of the video tutorials created by Ubicomp 2016/2017 students can be found on the dedicated YouTube channel: https://tinyurl.com/ybdrkgre (Instructional Videos, 2018).

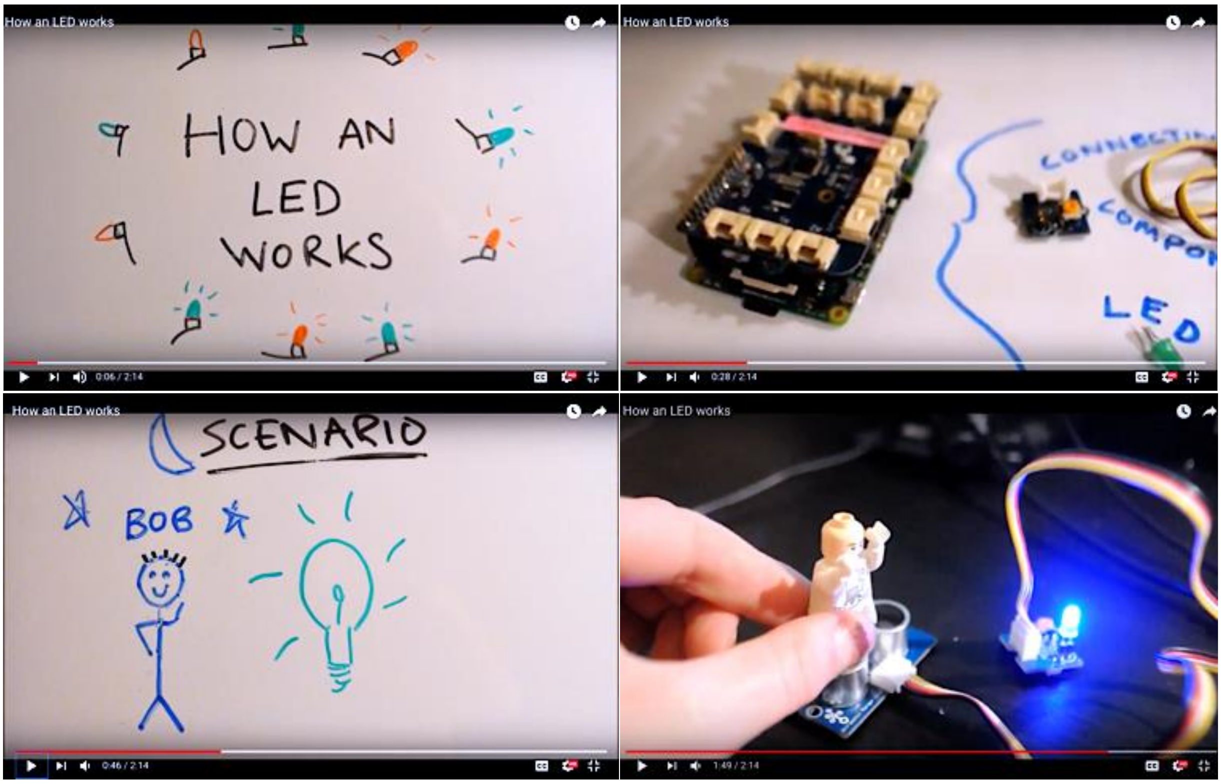

Figure 4:1. Screenshots from a video tutorial on working with LEDs and Raspberry Pi. This video was one of 19 videos selected for reuse in the second phase of the DSF.

In addition to creating video content, students were also tasked to create more traditional text-based artefacts. Specifically, in 2016/2017 and 2017/2018, a 40% component of the final course mark was assigned to writing answers to 'Big Questions' discussing Ubicomp issues in the form of blog posts. During the semester, the instructor asked the students to discuss 9 'Big Questions' on Ubicomp issues in an online forum. The questions included "What has Ubicomp research done for us?", "Will privacy matter in a Ubicomp future?", "Have toolkits such as Pi and Arduino democratised Ubicomp?", "Is GPS a good enough location sensor for self-driving cars? If not, what is?", and some others, with one question per week. The students were then encouraged (by getting up to 10% of final course mark) to contribute to these online discussions and use them as a starting point for their individual writing. See Figure 4:2 for an extract from one of the student-produced blog posts. Appendix B.1 contains the full version of this blog post, as well as 5 sample pages from the corresponding discussion forum thread. (The names of the students and the module leader were anonymised in all of the examples.)

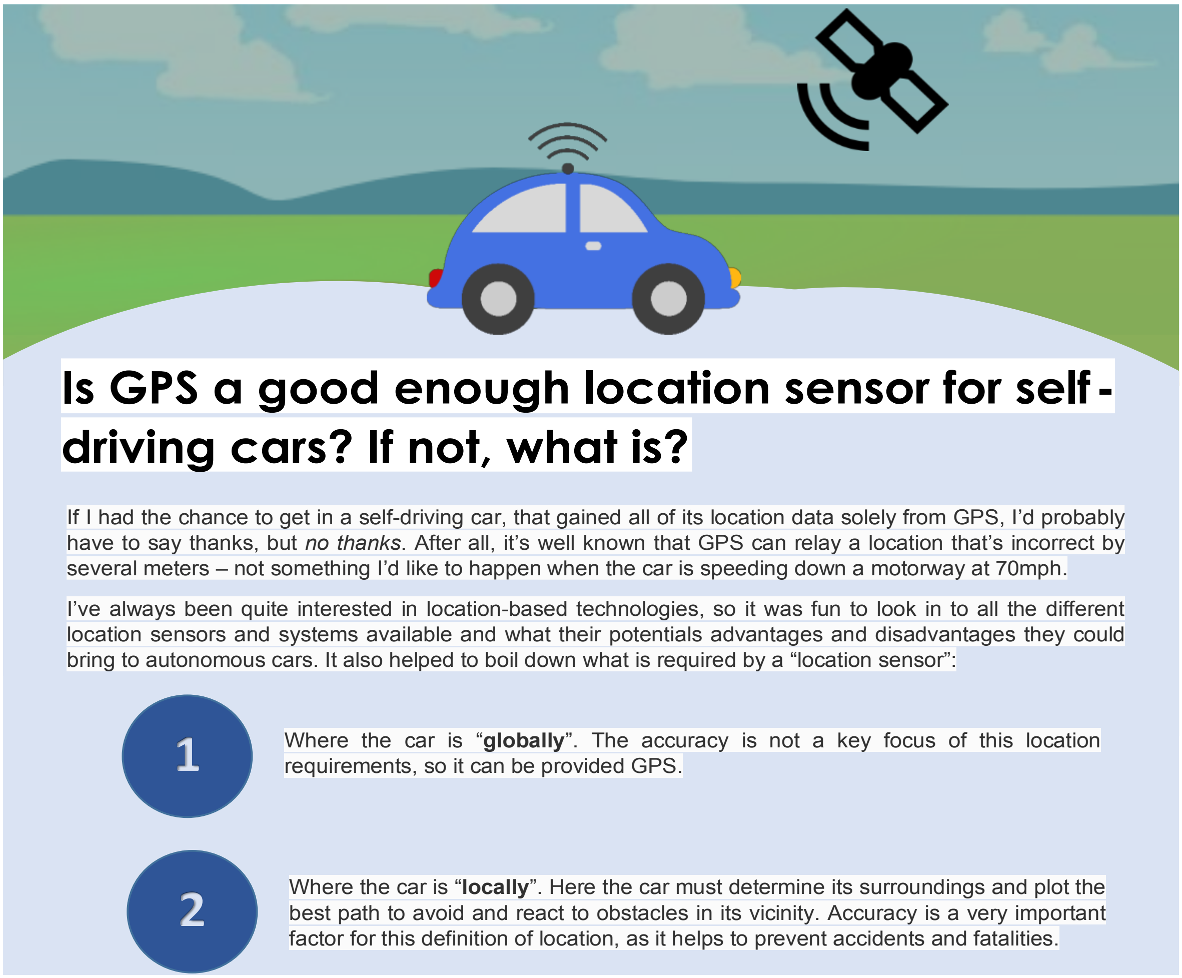

Figure 4:2. A screenshot of one of the student-produced blog posts.

The rest of the course mark was awarded for weekly quizzes and participation in both online and in-class active learning activities, such as discussions, fishbowl debates, small-scale research projects, presentations and prototyping. In the year 2015/2016, instead of blog posts, the 40% component of the course mark was given to the students for a text project report on a hackathon activity where they designed, prototyped, and documented Ubicomp technologies to help address the issue of social isolation of older people.

Although both the video and text artefacts were created with the intent to further reuse them as part of SFC teaching, only the videos had eventually been reused during the timeframe of this research project. In this thesis I report on the creation of the blog posts as an example of student-produced teaching materials but I do not present any data on their use for teaching other students. The following sections present details on the technology used to support students in creating the videos and the blog posts.

a) Bootlegger

To facilitate video making, the teaching team used Bootlegger (Bartindale et al., 2016), an open source collaborative video production tool which consists of a web and a mobile component. In the SFC spirit, the production of student video tutorials comprised two stages: *creation* and *reuse*. In the *creation stage*, the students used the Bootlegger's mobile application on their smartphones to create short video *clips* documenting their work during practical sessions, and later uploaded these clips to the Bootlegger's web platform. The uploaded clips were then made available for all of the students to see and use in their own *edits*, where an edit is a sequence of clips that forms the final video. According to the design of the activity, the students were allowed to use clips produced by all of their peers in their final videos, however they had to demonstrate their personal *editorial choice*, i.e. the thinking process behind the selection and arrangement of the clips into a sequence, to pass the assessment. Therefore, in the subsequent *reuse stage*, i.e. the second stage of the production, the students were required to combine clips into edits, to individually create their video tutorials, showcasing the learning outcomes of the practical aspects of the course, such as their abilities to design and prototype Ubicomp technology, and document the design and build processes.

The following aspects influenced the choice of Bootlegger for use in "Ubicomp":

i. *A collaborative environment:* Bootlegger is designed to allow users to share video footage, providing different points of view on the same step of a practical session. The students can therefore work together to make an all-round coverage of various different steps of their work. The created video clips can be readily reused by all students in making the final edits to be submitted for assessment. This approach provides students with an opportunity to examine and learn from how other students in their cohort convey technical details and create learning materials.

ii. *Ease of use:* the Bootlegger mobile application and the web platform are designed to be used by non-professionals, thus they are easy to use and require no prior skills in video capturing and editing.

iii. *It is a mobile application:* this allowed the students to use their personal familiar devices rather than having to worry about acquiring video cameras and learning how to use them.

iv. *The shoot templates:* Bootlegger provides a "shoot template" which is a set of suggested shots that the instructor can choose from to help guide students on what to shoot, and aid in framing their work better. The students are free to ignore the template and make their own choices.

The use of Bootlegger in this part of the case study not only allowed me to investigate a pioneering example of introduction of collaborative video creation as a form of compulsory coursework in an undegraduate course, but it also provided me with an opportunity to look deeper into the process of student collaborative video creation and reuse. Note that here the create-and-reuse cycle was very short, i.e. compressed into the timeframe of *days or weeks*, while on the other side of the spectrum, the create and reuse Phases I and II between the Ubiquitous and Physical Computing courses were separated by *months or years*. By observing the patterns of creation and reuse on such different time scales, I was able to build a broader picture of the SFC approach and collect comprehensive data for answering the research questions **RQ 2** and **RQ 4**.

b) Discussion Forum

To facilitate the collaborative part of blog post writing, the teaching team used an online discussion forum set up at the course website. An online discussion forum tool was chosen as a well-studied e-learning environment that "allows students to post messages to the discussion threads, interact and receive feedback from other students and instructor, and foster deeper understanding towards the subject under study" (Balaji & Chakrabarti, 2010). The use of online discussion forums has emerged over the last few decades as a common tool and an effective way of engaging students outside the classroom. Interaction within online forums was shown to benefit student-centred learning, encourage wider student participation, and produce more in-depth and reasoned discussions compared to face-to-face learning environments (Davies & Graff, 2005).

The forum was introduced during the second iteration of Ubicomp and provided the students with a way to discuss answers to the weekly Big Question topics. There were also two sub-forums, for technical support and for questions about course assessment where the students could post about any problems or questions they had on anything related to the course.

The use of the discussion forum for student text-based coursework was organised in exactly the same way as using Bootlegger for the video-based coursework. The first stage of the work, the *creation*, was collaborative, where the students discussed their answers to the posed questions online, presented their opinions, shared relevant references, and all the answers were available for everyone in the class to see. The second stage of the work, the *reuse and synthesis* was individual, where students used the materials from the forum discussions to create their personal answers to a chosen Big Question. This way the students demonstrated such learning outcomes as their ability to discuss current HCI literature and its implications for the design and evaluation of Ubicomp technologies, as well as to explain important issues, such as privacy and ethics, in the context of ubiquitous computing and relate them to specific design and deployment decisions.

Both video and blog post coursework are discussed in this chapter as an alternative way of course assessment and one of the steps in preparation for a Self-Flipped Classroom. A more detailed investigation of the impact of use of collaborative content creation technologies as part of student learning will be presented in Chapter 6 in line with the investigation of transferable skills acquisition that is supported by the SFC approach. In this chapter I focus on the outcome of student content creation (and its impact) rather than on the process of the creation itself.

4.2.2 Methods

This section provides a detailed description of the methods used at each stage of data collection and analysis used in Phase I of Case Study A. I also introduce the research participants. Data collection took place in the period from 2015 to 2018, and each iteration of Phase I intended to answer different research questions of this study, therefore the research methods were also different. Not all methods are presented in this chapter in full as some of them are more relevant to the results presented in Chapter 6; in particular, the methods used to investigate student acquisition of transferable skills will be described in details in Chapter 6. Below I introduce the methods that were used for answering the research questions on instructor and student attitudes and experiences as part of Flipped and Self-Flipped Classrooms.

a) Iteration 1

The first iteration of the Ubiquitous Computing course was in the year 2015/2016. That year the course was completely restructured, turning it from a traditional lecture-based module to a fully Flipped Classroom module. This provided me with a valuable opportunity to observe the process of flipping a course, as well as the development of the instructors' motivation to go beyond a 'standard' Flipped Classroom teaching, towards the Self-Flip. I collaborated with the course instructor in order to get permission for the observation of the whole course planning process: I was present at the teaching team meetings, had access to the course documentation, and was granted admin access to the course website. Following that, I observed the actual teaching process: I was present at each of the course seminars and practical sessions, was allowed to invite students to take part in interviews, had access to anonymised student coursework and metadata from the Bootlegger platform, and had access to anonymised student feedback on the course at the end of the semester.

Research participants

The first group of research participants were the instructors who were part of the teaching team that developed and run the course for the first time in that year. The teaching team comprised the module leader; four invited field experts, who helped the module leader with development and delivery of materials for specific topics; a lead demonstrator; and a technical support person.

Their roles and responsibilities in the team were as follows:

Module leader (a lecturer in the School of Computing at Newcastle University): she was responsible for decisions about topics for each week session; choosing and inviting the field experts for each week; reviewing all the materials for each week; managing the activity planning sessions; preparing all coursework assessment; shooting introductory videos for every week; leading all the classes and some of the practical sessions; being the main contact point for students during the course; doing a part of the coursework marking; and also preparing Bootlegger templates for the video shooting.

Field Experts (4 Research Associates at the School of Computing at Newcastle University, specialising in one of the ubiquitous computing topics covered in the course, e.g. context awareness, accessibility, etc.): they were responsible for writing scripts for introductory videos; presenting for the videos (headshot or video scribe); writing a blog post to initiate further discussion; choosing the reading materials (academic papers); preparing a quiz (5 multiple-choice questions) based on reading; planning activity sessions for the Flipped Classroom seminars; helping to deliver the teaching at the seminars for their weeks.

Lead demonstrator, who also acted as a field expert for one of the weeks (a Research Associate at the School of Computing at Newcastle University): he was responsible for planning of all practical sessions in the labs; preparing necessary materials and tools for all learning activities; managing/delivering the practical sessions; and fulfilling the responsibilities of a field expert for one week.

Technical support (a PhD student in the School of Computing at Newcastle University): she was responsible for the design, development and maintenance of the course website; filming and editing the Flipped Classroom videos; monitoring the website during the course for technical issues; publishing weekly updates and materials to the course website; monitoring student participation and contribution.

All of the teaching team members agreed to take part in the interviews describing their experiences in teaching this course. See the Appendix B.2 for the corresponding information sheet and the consent form that were given to the instructors before the interview.

The second group of research participants were the students who completed Ubiquitous Computing course in the year 2015/2016. The class comprised 34 students; 85% of them were male; all students were third year undergraduates from the School of Computing except for one student who was from Civil Engineering. At the beginning of the course, all students who signed up for it were informed about the research aims and it was made sure that every student either gave their consent to participate in the study or was excluded from individual observation. Whole classroom observations were fully depersonalised, and all of the students agreed to that. Furthermore, all students gave their consent for the anonymised artefacts produced during the course and the metadata from Bootlegger associated with those artefacts to be used in data analysis. See the Appendix B.2 for the corresponding information sheet and the consent form that were given to the students before the data collection. These forms were distributed to the students electronically (sent by instructor via email) and also physically (printed copies handed out during the first in-class session).

Data collection and analysis methods

Three data sets were collected in this part of the study: the first two were qualitative sets comprising semi-structured interviews with instructors and with students; the third data set used mixed methods with the majority of the data being quantitative (this data was used solely in the media literacy study, see Chapter 6, Section 6.1). Below I only describe the first two sets of data.

The collection and analysis of the **first data set** were guided by the research question **RQ 3**:

RQ 3: *What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

Since the studied course was not an SFC course yet, I was looking at the instructors' experience of preparing and running a Flipped Classroom course, bearing in mind that the FC and SFC settings are fundamentally very similar. In addition to collecting data on instructor attitudes and experiences relevant to answering the **RQ 3,** this investigation pursued the following two goals:

(i) gain a practical, in addition to a theoretical through literature, understanding of the FC-related instructing challenges; (ii) identify opportunities for alleviating these challenges by reusing student-produced materials as per the SFC approach, and thus preparing the ground for Phase II of this study.

This data set consisted of 7 interviews conducted with each member of the Ubicomp teaching team. The focus of these interviews was on their experiences during preparations for and delivering of the course, as well as on their attitude towards the Flipped Classroom model of teaching in general. The interviews were conducted at the end of the course to allow for the reflection on the whole experience of preparing and running Ubicomp. The participants discussed the time spent on preparation of the module, dealing with Flipped Classroom video preparation in particular, and the novelty of designing seminars with the new teaching model. The questions of the interview included:

1. Would you tell me about your experience of teaching for Ubicomp module in general?
2. How much time did you spend to prepare the video part of the lecture? (both headshots and video scribe)
3. How did you feel about making videos? (How comfortable were you with video making?)
4. Was there anything particularly new that you had to learn in terms of teaching/preparations?
5. Do you think the course was a success?

The full interview schedule is available in Appendix B.3.

The interview transcripts were analysed using inductive thematic analysis. I was specifically looking for recurrent themes in the form of phrases and sentences associated with the instructor team experiences of Ubicomp. The following themes emerged as the most prominent: workload; comfort and confidence of doing video production (both being on camera and being the author of something that will be *live* for long time); and comparison with other teaching experiences. In order to improve the validity and trustworthiness of the analysis, the evolving themes were first checked with a more senior researcher (a member of Open Lab, expert in qualitative research, not involved in either this case study or teaching of Ubicomp). He read and coded a sample of data comprising one half of the longest of the collected interviews, thus checking about 10% of the whole data set. We calculated the intercoder reliability, i.e. the degree of agreement among the two coders, using the SPSS statistics platform and found the

Cohen's Kappa coefficient to be 0.75, which indicates substantial agreement according to Landis and Koch's recommendations (Landis & Koch, 1977).

As an additional validity check, after the first cycle of coding of the data set, I performed member checking by asking two of the interview participants for their view on my understanding of the data. Their evaluation of my coding was positive. They generally agreed with all of the codes, and only expanded or refined some of them, which was helpful for the second cycle of the data analysis where I did summarisation and grouping of the codes.

Collection and analysis of the **second data set** focused on student learning through content creation, which contributed to answering **RQ 2A**:

RQ 2A: *What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*

The data comprised 8 student interviews conducted after the course. The interviews were semi-structured, face to face, and each lasted about 30 minutes. The participation was voluntary, and 8 out of 34 students (i.e. 24%) were recruited. These interviews were meant to add to the understanding of the student experiences of learning through creation of video artefacts as part of their coursework. Therefore, the interview schedule included the following questions (see the full list in Appendix B.3):

1. How was your experience in Ubicomp?
2. What do you think of the assessment and the coursework in the course?
3. How do you feel about making videos rather than writing reports for the practicals?
4. What do you think of Bootlegger?

The interview transcripts were analysed using inductive thematic analysis. The emerged themes were checked with another researcher (who was also a teaching assistant at the same course), obtaining the Cohen's Kappa coefficient of 0.82, thus showing a strong agreement (Landis & Koch, 1977). I also performed a member check asking feedback on my coding from two students who after competing their undergraduate degree stayed at Newcastle University to continue their study on a graduate level, and hence were available for contact.

b) Iteration 2

The second iteration of the Ubiquitous Computing course was in the year 2016/2017. The participants of the study were third-year students in the School of Computing, Newcastle

University, who signed up for the Ubiquitous Computing module. The class consisted of 48 students (8 females and 40 males). At the beginning of the course, all students who signed up for it were informed about the research aims, research methods involved and the measures put in place to protect their privacy. It was made sure that every student either gave their consent to participate in the study or was excluded from individual observation. Whole classroom observations were fully depersonalised, and all of the students agreed to that. Furthermore, all students gave their consent to include their anonymised artefacts produced during the course, as well as the metadata from Bootlegger associated with those artefacts' creation, into my data analysis. See the information form provided to the students in Appendix B.2.

Data collection and analysis

The first data set consisted of 9 student interviews. The interviews were semi-structured, each about 30 minutes long, conducted face to face after the course. Similarly to the Iteration 1, the focus of the interviews was to understand student experience of learning through creaton of multi-media artefacts. The core of the interview schedule was the same as in Iteration 1, see Appendix B.3. The same research question guided the data collection and analysis:

RQ 2A: *What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*

The interview transcripts were analysed using inductive thematic analysis. Similarly, to the Iteration 1, I was looking for recurrent themes relevant to student attitudes and experiences. The procedure of data analysis was exactly the same as in Iteration 1.

The second data set includes Bootlegger metadata, forum metadata, and student artefacts. Furthermore, unlike the Iteration 1, I also include here some of the questions from the student interviews, which focused on student attitude to and experience of collaboration during artefact creation. The student artefacts comprised all videos (both pre-production clips and final edits) and texts (discussion forum threads and final blog posts) that students created as part of their learning in the course. All of this data contributed to answering the research question **RQ 4**, i.e. the investigation of transferable skills promoted by SFC, which will be presented and analysed in detail in Chapter 6, Section 6.2 (Collaboration and Attribution).

c) Iteration 3

The third iteration of the Ubiquitous Computing course was in the year 2017/2018. This year the course leader has changed. The new course leader preserved most of the elements of the course, such as the Flipped Classroom structure as well as video and blog post coursework, however, Bootlegger was no longer used because it was undergoing redevelopment and was not stable enough to be used by many people at the same time. Therefore, in this iteration my focus was only on students' attitudes and experiences. To increase the number of responses compared to the earlier iterations, the data collection was changed from interviews to a questionnaire with a mix of multiple-choice, Likert scale and open-ended questions.

Furthermore, this year, for the purpose of improving generalisability of the study as well as strengthening the results obtained from the interviews thus far, I decided to probe attitudes towards the SFC ideas among wider student population. Consequently, a questionnaire with questions related to learning from watching videos and creation of sharable artefacts was distributed among all students studying STEM subjects at Newcastle University.

Research participants

There were two groups of research participants: (i) students of the Ubicomp course 2017/2018; and (ii) all students of STEM subjects in Newcastle University in the year 2017/2018.

The Ubicomp cohort that year comprised 48 students. As in the previous iterations, all of them were third-year undergraduates from the School of Computing. The study was explained to the students in the first seminar and they were informed that they could ask to be excluded from any individual observation anytime they wanted to. The invitation to complete the survey was distributed to the students at the end of the course and the participation was voluntary. See the information form provided to the students in Appendix B.2.

The second group of participants comprised 121 survey questionnaire respondents. Among them 74 students (61%) studied Computer Science (74 students make up 9.3% of total 800 CS student population) while the rest came from different engineering programmes, such as Electrical and Electronic Engineering, Mechanical Engineering, and Chemical Engineering. There was a good distribution of students with regards to their level of study: 35.5% from the first year, 25.6% from the second year, 28.9% from the third year, with the remaining 10% being from either the placement year or the fourth year (i.e. on integrated Masters degrees). 74.2% of the respondents identified themselves as male, 24% – as female and only one student (i.e. 0.8%) chose the "prefer not to say" answer. The age distribution was as following: 48.8% of participants were 20-21 years old, 29.8% were 18-19 years old, and 21.5% were 22 years old or older. 89 students (73.6% of respondents) were originally from the UK, 4 students (3.3%)

from China, 3 students (2.5%) from Lithuania, while 19 other countries (e.g., Poland, Bulgaria, Indonesia, Cyprus and Singapore) were each represented by 1-2 students (i.e. less than 2%).

Data collection and analysis

For the Ubicomp students, the data was collected and analysed with the **RQ 2A** in mind:

RQ 2A: *What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*

The questionnaire was distributed to the students electronically via a link to Google Forms at the end of the semester. The students were asked 11 Likert scale and multiple-choice questions and 1 open-ended question. 17 students out of 48 (i.e. 35%) filled in the questionnaire.

The full questionnaire can be found in Appendix B.3. Below are a few question examples:

1. I like the idea of creating learning materials for someone else as part of my own learning.

Strongly disagree	1	2	3	4	5	Strongly agree

2. I think this coursework has helped me to learn the course material better.

Strongly disagree	1	2	3	4	5	Strongly agree

3. Knowing that my final artefacts (tutorials and blog posts) will be used by other students would impact my learning during their creation.

Strongly disagree	1	2	3	4	5	Strongly agree

4. In general, I like the idea of using some materials and resources, that other students previously produced, for my learning.

Strongly disagree	1	2	3	4	5	Strongly agree

5. I think types of coursework that require multimedia creation (e.g. video or creative text) are helpful to develop skills that will be useful in my future career.

Strongly disagree	1	2	3	4	5	Strongly agree

The questionnaire for other STEM students was similar to the one for Ubicomp students. However, the corresponding data collection and analysis were guided by the first part of **RQ 2** with the focus on **students' attitudes**:

RQ 2: *What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

This questionnaire was also administered online via Google Forms and was a mix of multiple choice, Likert scale and open-ended questions. The complete list of questions that were used can be found in Appendix B.3. Several example questions are listed below.

1. I think that I learn best by:
   - ☐ Listening to lectures in class
   - ☐ Reading textbooks, articles, etc.
   - ☐ Watching instructional videos
   - ☐ Listening to podcasts
   - ☐ Doing practical exercises
   - ☐ Other:
2. I would like the idea of creating learning materials for someone else as part of my own learning.

Strongly disagree	1	2	3	4	5	Strongly agree

3. I believe this kind of coursework would help me to learn the course material better.

Strongly disagree	1	2	3	4	5	Strongly agree

4. I would like other students to find my materials useful for their learning.

Strongly disagree	1	2	3	4	5	Strongly agree

5. I believe that sometimes students may be able to explain parts of course subjects to their fellow students more clearly than the instructor.

Strongly disagree	1	2	3	4	5	Strongly agree

The data from both questionnaires was analysed using the same method. The answers for open-ended questions were analysed inductively, similarly to the analysis of the interview data in previous iterations. The analysis of data from close-ended questions was exploratory, rather than testing a pre-formulated hypothesis, hence descriptive statistical methods were used to simply illustrate the student's attitudes to non-traditional teaching and learning methods. For example, I used frequency distribution analysis to explore STEM students' preferences to the delivery of teaching materials: traditional lecture, watching a video, or doing a practical exercise. At the same time, I used the central tendency and variability measures to explore how students would feel about creating teaching materials for other students' learning. This all was helpful in answering the attitude part of **RQ 2**.

4.2.3 Results

This section presents results of Phase I of Case Study A. The results are organised in two parts, covering the instructor and student experiences, respectively.

a) Instructor experience

In this section I discuss the instructor experience of preparing and running a Flipped Classroom course, covering the *challenges* (such as the high amount of effort needed for the preparation and difficulties encountered during the run) as well as the *opportunities* offered by the Self-Flipped Classroom in addressing some of these challenges while preserving the advantages of the FC. In the end, my goal is to provide answers to the research questions **RQ 3** and **RQ 3A**.

The conducted inductive thematic analysis of the data revealed a number of themes which could be grouped into two larger themes as following:

1) **Preparing and running a Flipped Classroom:**
    a. ***workload;***
    b. ***comfort and confidence associated with video production;***
    c. ***working in a large teaching team;***
    d. ***teaching experiences.***
2) **Supporting student artefact creation:**
    a. ***technical issues (with Bootlegger and video submission);***
    b. ***students' understanding of non-standard coursework;***
    c. ***resulting artefacts (quality/reusability).***

Below I present each of these themes in detail.

Preparing and running a Flipped Classroom

The Ubiquitous Computing module was restructured from a traditional lecture-based module to a full Flipped Classroom module in 2015, which motivated me to use it as a case study for my research. This was a unique opportunity: I could closely observe the process of "flipping" the module over the course of my PhD study and, furthermore, I could study the development of the motivation of the teaching team to go beyond a "standard" Flipped Classroom teaching towards student content creation and reuse of the resulting artefacts.

The case study commenced with observations of the teaching team. I started by attending the course preparation meetings of the team, which helped me to better prepare for the seminars. These initial observations were not meant to generate any data, but they were used to provide me with the comprehensive understanding of the course settings.

The actual data collection commenced by interviewing the teaching team about their preparation and running the flipped module. The interviews revealed a number of challenges, in particular: (i) a large ***workload*** and the lack of time to prepare all materials in advance; (ii) ***inexperience*** of many of the team members in making multimedia teaching materials; and (iii) management issues related to the unusually ***large teaching team***, which involved overcoming the miscommunication about the course goals and standards, as well as accepting a mismatch in motivation and incentives of the team members who were not regular teaching staff yet had to contribute their teaching content in time. Despite all of these challenges, all but one of the teaching team members expressed a ***positive attitude*** towards the Flipped Classroom approach, i.e. the delivery of teaching materials in advance to allow for the in-class time to be spent for active learning activities.

The most prominent theme of this part of the data was the increased ***workload*** in the course preparation, which is closely related to the inexperience of the instructors in producing video lectures and linking them to the in-class activities. Therefore, below I will present the theme of ***comfort and confidence associated with video production*** alongside the ***workload*** theme.

None of the teaching team members had a prior practical experience of flipping a course from scratch, so they had many concerns about how to prepare for the course, what decisions to take regarding the quantity of delivered information and format of teaching materials, as well as how to organise seminar sessions based on non-traditional active learning. The video teaching materials were the biggest concern because they were very difficult and time consuming to make, and the effect of them was the least understood. All of the instructors felt *"a little bit nervous about doing the video lectures"*; they had to invest a lot of time in making them, and they *"did worry that maybe the students weren't getting enough of the material about the subject and that maybe the classroom didn't connect to that as much as it could have"*. In the end, it was disappointing for the instructors to find out that the students did not fully appreciate those efforts. After seeing the course statistics, the module leader commented:

> *"Data seem to suggest that they [students] stopped watching the videos quite quickly. So, it's not really clear to me if that's just 'cause they didn't like the way the videos were made or they didn't think they were good enough quality, or if actually it's quicker for them to read the blog post than to watch the video, or easier for them somehow to maintain attention."*

Themes ***workload*** and ***comfort and confidence associated with video production***: The increased workload in preparation of the course materials, and the delay in the course preparation associated with it, were caused by the inexperience of the teaching team members in creating multimedia materials and their aspiration to prepare good quality content. One teaching team member said:

> *"I think to make the online content for the Ubicomp course was more time consuming because it [the final video] is there available online and it's, sort of, there almost permanently. So, you want it to be as good quality as you could possible make."*

Moreover, about half of the teaching team specifically noted that they felt uncomfortable in front of the camera, they noted that it was easier for them to teach in front of the class. Those who could not overcome their "fear of camera" eventually chose to use a tool for video handwriting (VideoScribe) – it was longer to learn and much harder to use, but it did not involve any camera, only audio recording for the voice over. *"I spent ages, I'm embarrassed",* said one; *"it could take me one working day at least per VideoScribe even though it was just five minutes long",* said another field expert.

Theme ***workload***: Overall, in spite of the difficulties and pressures to produce good teaching materials, all but one instructor agreed that the effort was worthwhile. The instructor who disagreed questioned the amount of his time spent on the preparation for the module, i.e. making the Flipped Classroom materials. He said:

"The reason I'm not convinced is imagine if you had the same amount of resource being spent on individual tutorials, you'd probably get a lot more receptive audience from a class than you would… The amount of resource put into that module is way more than the amount of resource that's put into normal modules, and it was a small enough class to begin with, it was a class of 30 people. I do have some sort of question whether my time was best spent preparing videos, which is about a week worth of time when you've written material, or if I spent my time doing one on one... I could, in theory, in that period of time have given one on one tuition to three or four students in quite an intensive way."

But then he also added:

"I've got to learn how to do videos which I wasn't used to doing at all. I'm not particularly a fan of doing videos on the Internet personally, but maybe that's something I haven't been trained in properly."

Although it is easy to agree that giving one to one tuition to students is an effective way to teach, such efforts would only benefit those "three or four" students (which is about 10% of the whole cohort) who came to the one to one meetings. The created online materials, however, were available for all students to learn from and there were intended to be reused in future iterations of the module. This suggests that this instructor did not fully appreciate the "time investment" benefit of the Flipped Classroom approach. Moreover, as his confidence in making videos will have most probably improve after the first run of the module (inferring from the second quote), next year, if there is a need to remake a certain part of the materials, he would likely be able to do it with less effort.

The theme of ***working in a large teaching team*** mostly concerned the course leader, who needed to manage everyone in the team and lead them to the the same goal, and the technical support person, who needed to assist everyone in their teaching materials preparation and made sure everything was ready for the students on time.

As per the design of the course, the course leader's responsibility was not just to prepare the teaching materials herself. She also had to assign preparation of content specific to the expertise of each of the field experts and to make sure that that material was prepared in time and of adequate quality. To make matters more difficult, all teaching team members did FC for the first time, and none of them had skills of making multimedia teaching materials.

As for the technical support person, who was assigned to help every other teaching team member in making their videos, and who spent 6 months working for this course (before and during the semester), it usually took them about 1 hour to shoot the footage plus 1 hour to edit it to produce material for a 5-minute video lecture. Moreover, for the first several videos when everyone was still learning, making 5-minute video lecture would take up to the full working day. She also commented on the challenges in achieving the desired video quality. There was no professional studio setting available, so the video making was done in small meeting rooms placed in an open office environment. Consequently, background noise was a frequent problem. Last but not least, the technical support person admitted that it was *"hard to handle some people"*, referring to those who (i) were uncomfortable in front of the camera, or (ii) did not know how to *"put together"* their video lectures, or (iii) needed to be *"chased"* to make the materials on time. Overall, the whole experience for her's was very difficult and she said "*I would not say I enjoyed it"*, although further adding: *"I am satisfied with the work I've done"*.

To finish this part with a rather broad theme of ***teaching experiences***, I would like to hightligh how the instructors felt about their Ubicomp teaching. The module leader admitted that her experience of preparing and running Ubicomp was quite chaotic in the beginning and demanding but enjoyable during the semester: *"So, my experience of it was that there was a lot of efforts put into it and at times it felt like effort paid off but not always"*. In the interview, she recalled that in spite of all the efforts to prepare for the course well in advance, during the summer, at the beginning of the semester they only had about half of the course ready: "*so, I felt quite panicked about it. I wasn't at all optimistic about the how the course was going to run*".

Theme ***teaching experiences****:* The module leader was also concerned about how the 3rd year CS students would react to the new teaching format because she knew that an absolute majority of the other courses that they had so far were based on classical teaching:

> *"I taught to the computing science student here for 4 or 5 years and I know them to be in general quite anti the use of non-traditional methods in teaching. They normally don't respond to it very well, they find it patronising, they are thinking it's a primary school stuff."*

In part, her concerns were justified as the end of course when the course evaluation turned up to be highly polarised. It was clear that the students' attitude towards the course was divided into 'love it and hate it'. *"I think some of them either felt like flipped classes in particular were* *really good 'value for money' or they were completely meaningless. I think that probably would tie back to the kind of student that they are, what kind of learner that they are".*

Theme ***teaching experiences***: Despite all of the challenges that the teaching team experienced, all but one of them were still convinced that Flipped Classroom format was valuable and provided a great opportunity for the students to learn well. One of the field experts said: *"I think overall it works quite well because it's a less formal form of teaching in the classroom and the time in the classroom is used better".* Another teaching team member further commented that the students *"became a lot more actively involved"* when they were taught in the Flipped Classroom format and *"that it really puts them in a powerful position to learn more"*.

The module leader's general experience during the semester was more positive than she expected. She commented on it:

> "*My experience during the module was actually that it was going much better than I had anticipated. I thought that students really enjoyed the practical classes and stuff we were doing with Raspberry Pi. And I thought that we really delivered some good learning experience for them."*

Theme ***teaching experiences***: Another member of the teaching team commented on his general experience of the flipped course, also mentioning the challenge of video recording:

> *"I really liked it, I thought there was a lot of opportunity to give the students something a little bit different. Think that students learnt better because the format of the course motivated them to prepare for the class… The only bit I didn't like was trying to record the video for the flipped class. I hate being recorded."*

This suggests that although preparation for a Flipped Classroom course was stressful and difficult, most of the teachers appreciated the benefits of the format for the students. The experience of the teaching team in Case Study A suggests that they would benefit from an additional support in the preparation of the video materials.

Some of the field experts made interesting remarks about their experience of video making. One said: *"video format is a different approach to think about content presentation"*. While the other elaborated further:

> *"I actually really liked that because it made me really think about what I was trying to get across and why it was there and I think that's really important… So, this idea*

about getting all the content down in one place and then thinking about the flow, what's the most important message, what do you need to know next and then why is this relevant; it puts everything into a really nice context."

It is interesting to relate these observations on the instructors' experiences to the experiences of the students asked to do the same task: create a mini video lecture or tutorial. I will do so in the next section.

To conclude, the experiences of the instructors were very different from their teaching of other, non-flipped courses. It was difficult as they didn't know what to expect and how the students would react, and had no previous experience in video making. The preparation was extremely time consuming, which resulted in the course being only half ready by the start of the semester. The work of a large team was hard to coordinate. However, the majority (all but one) of the instructors on the team believed that the FC format allowed them to deliver a better learning experience for the students by providing the settings for quality active learning. Furthermore, personal practise of video making prompted the instructors to think how the action of short video creation was helpful for structuring the thoughts and ideas intended for the delivery.

The above summary of the instructors' experience and attitude answers the research question **RQ 3**. It also brings us to the question of how the above challenges can be alleviated by introducing the 'Self' component into the classic Flipped Classroom approach. By offloading the production of some of instructional videos to students, it is possible to reduce the extreme workload on the teaching team. By introducing video making into the course assessment as part of Case Study A, it was possible to study the amount of support and scaffolding required for the students to produce video artefacts suitable for the reuse as teaching materials in future.

Supporting student artefact creation

We now switch our focus to the second large theme of this data analysis, one specific aspect of the instructors' experience. Specifically, their experience of supporting the students in creating video artefacts, where the students were asked to use an innovative technological solution for collaborative creation of video tutorials.

As has been explained earlier, a large portion (30%) of the course assignment was dedicated to student-produced video tutorials, which is of particular interest to this research. The assignment was carefully thought through and specifically organised in the way that ensured that: (i) the students work collaboratively, thus learning from each other, yet at the same time (ii) they submit individually edited tutorials and therefore receive individual course marks. As a result, the coursework supported student peer learning and encouraged their individual accountability and creativity at the same time.

The videos themselves were meant to replace a more traditional assessment, such as a written report on practical work. Therefore, the following main categories of a written report were also expected to be present in a produced video: a full understanding of the reported task, clarity of the described steps to achieve the intended result, as well as a broader understanding of the significance of the presented topic, which could, for example, be demonstrated by placing it into a wider context. Moreover, the produced videos were required to be instructional, i.e. suitable for teaching other learners, thus building on the idea of *learning by teaching*. The specific marking criteria for this assignment included:

- Provision of good detail for all the necessary steps to complete the task using Pi.
- The presented steps are organised in a logical order to make it easier to follow.
- Consideration of a learner's needs providing all necessary information visually and by narration.
- Appropriate choice for the use of captions, graphics and other media.
- The presenter's speech is clear and uses accessible language at a legible pace.
- Good editing choices and variations in speed, tone and shot, to maintain interest and engagement in the video.
- Demonstration of outstanding creativity in the approach to video creation (a bonus to get an "Outstanding First" mark).

The detailed marking scheme has been made available for the students and was also discussed in class in order to ensure that everybody understood what was expected from them. See the full marking scheme in Appendix B.1.

During the first iteration of the Ubicomp, the use of Bootlegger was not optional for students, as the tool seemed to be working well and had already been tested by a large number of people in various usage scenarios. Therefore, all the students who attended the practical sessions were expected to use the tool to document their work in the labs. To accommodate for such cases as the absence of a suitable smartphone or an inability to shoot videos (e.g. due to autism), students were allowed to work in pairs or small groups. The instructors also provided several extra smartphones that were available for borrowing during each practical session. In the interview with the module leader, she commented that Bootlegger was chosen and made non-optional specifically due to the ease of access and use, which allowed all of the students to capture and share what they were learning collectively in practical sessions, and enabled the subsequent production of video tutorials explaining the usage of the Raspberry Pi kit to others.

The theme that dominated intstructors' interviews when talking about student video makining was ***technical issues.*** This part of the coursework did not go entirely smoothly due to a few technical issues with Bootlegger. Both the mobile application (used for shooting video clips) and the web application (used for editing final videos) experienced scalability issues and the more of the students used Bootlegger simultaneously, the more likely it was to crash, which was especially problematic at the time near the coursework submission deadline, when the majority of the students were all editing their final videos. Students expressed their concerns about the tool and negatively commented on the fact that they were asked to use an early version of an unstable tool, and how that was disturbing for them during the time before the coursework deadline. This caused a lot of stress for the module leader, as she recalled with her eyes getting wet:

> *"The least enjoyable moment of the course was the week of the Bootlegger, sort of catastrophe. I felt like I was on sort of high levels of anxiety from the 8.30… 8.15 that I've got into work on a Monday to run the practical to discover that over the weekend students have gone like a bit of ballistic on Twitter about Bootlegger all the way through to the Thursday deadline. It took me a long time to emotionally recover from that week and I was working all out… me and Tom [Bootlegger developer] were responding to emails from students at, sort of, half nine, ten in the evening."*

She felt demoralised because despite all of the efforts that she and others have put into the course and their ambitions to provide the best learning experiences possible, that glitch in the application *"has tarnished"* the whole course. The student attitude was spoiled and that was shown in the course evaluation, regardless of every attempt to mediate the effect of the glitch. The tool eventually was fixed, preserving all of the students' work in the Cloud, and the deadline for the student video submissions was extended to rectify the disruption.

During the subsequent course iterations, Bootlegger was presented to the students as a desirable tool for all video creation, however, the students were free to choose any other video editing tools to complete their projects. The instability of Bootlegger was particularly noticeable in the final video editing function, while the other functions used to generate pre-production materials, e.g., shooting video clips documenting the students' work, worked well. Importantly, all of the clips that were shot and uploaded to the shared cloud, were still available for all of the students, so they could download them from the cloud and edit in another software environment. Thus, the collaborative part of the project was preserved and the students who started to experience serious problems with Bootlegger swiftly switched to more mainstream and reliable applications, such as Adobe Premier or Apple Movie Maker. Thanks to this, in the end, the amount of negative feedback was minimal.

Continuing with the theme of ***technical issues,*** instructors faced one more problem related to assessment of student work through video making, that was the lack of a standard set up for handling of video coursework submissions. Some of the students uploaded their submissions to a private YouTube channel and then simply shared the link with the marking team. While others used the university submission system which had a harsh limit on the submission size, thus requiring significant video compression that led to visibly poorer quality. The instructing team commented that better support for videos in the university coursework submission system would have simplified the process and saved time both for the students and the instructors.

Another important theme that emerged from instuctors' interview was ***students' understanding of non-standard coursework.*** The level of student understanding of the relationship between the taught material and the assessed work was the second challenge that the instructors experienced due to the introduction of video making as a coursework in a Computer Science course. In particular, despite the efforts to make sure the students were aware of how video tutorials represented the learning outcomes of their practical work, some students felt that the link between practical sessions and the final assessment was poor. Reflecting on this, the module leader said: "*I need to be clearer regularly throughout the course about why specific pieces of assessment are required, and how these activities will support students' ongoing learning".* Moreover, in the first iteration of the Ubicomp course, the video coursework was due for submission right at the end of the semester, with only one intermediate opportunity for (optional) formative feedback. As a result, some of the students did not appreciate the amount of work and level of engagement with the material that was required. Therefore, for the subsequent iterations of the course, the module leader decided *"to move the deadline for this assignment forward to encourage students to engage with the video material, reflect on their communication skills, and improve their video making with more time before the deadline."*

The final theme from the instructors' data was the ***resulting artefacts*** from student coursework. Only the course leader was commenting on this, as the rest of the teaching team did not take part in the assessment of the student coursework. Ultimately, despite the abovementioned problems, the course leader was generally happy with the work that the students were able to produce. According to her, as in any other course some students were lazy and produced only bare minimum to pass the assessment, while "*many of the end results of this coursework are fantastic*". She also added:

> *"Bootlegger was obviously at times a bit of a disaster but on reflection they produced really good quality materials, some of them. And actually, I think it was a good learning experience. It was difficult at a time, but sometimes learning isn't supposed to be easy…"*

The best examples of the student created videos included elaborate scenarios for use of a particular Ubicomp technology or demonstration of creative prototypes. Some students used humour, some demonstrated their other creative skills such as drawing or acting. Overall, during each of the three iterations of the course, a large number of video artefacts suitable for reuse were produced. A collection of them was eventually reused in Phase II of this Case Study.

The overall quality of produced artefacts can be seen from the assessment outcomes of all of the three Ubicomp iterations. The marks for this part of the coursework had averages in the 'Upper Second' category (i.e. above 65%). Additionally, this was also supported by student comments in the interviews and course feedback, with many of the students saying that they were proud of what they had made as a result of this assessment, and that this coursework helped them to learn how to better communicate technical ideas.

To conclude, using student-produced videos for assessment led to challenges as well as rewards for the instructing team. There two main challenges were: (i) technical issues with the video creation and submission systems that could not cope with the high number of students editing the videos simultaneously and with the large sizes of the resulting artefacts, and (ii) the lack of students' understanding of the relationship between the taught material and the video tutorials that needed to be produced for assessment. The first challenge can be directed to the HCI and education communities: there is a need to develop better tools for using collaboratively created videos in assessment. The second challenge can be overcome by providing students with more background information on how to understand and be productive with new form of assessment, as well as give more frequent formative feedback during the course. The main reward for the instructing team was the resulting library of high quality and reusable teaching materials produced by the students (which will later be reused in Phase II). These materials demonstrated the students' good practical skills and understanding of the taught subject, as well as the development of their video creation and story-telling skills.

Having discussed the instructors' experience, attitudes and challenges, thus addressing research questions **RQ 3** and **RQ 3A**, we can now move to the experience of the students.

b) Student experience

This section presents the results of observing and interviewing Ubicomp students, focusing on their experience of learning through making. These results help me to answer **RQ 2A**. The section also presents the results of probing the attitude towards the SFC approach from a wider population of STEM students at Newcastle University, which adds to answering **RQ 2**.

It is worth noting, that for almost all of the Ubicomp students, it was their first ever Flipped Classroom and learning through making experience. In the interviews, the students often commented about how different the course was from anything else they had experienced in the university thus far. 5 out 9 interviewees in the first iteration and 7 out of 8 in the second iteration also described the course as enjoyable, and a total of 10 students from these two iterations even said that it was their favourite course. These praises, however, should not be treated as completely representative of the whole cohort because, as with any self-selected sample of interview participants, there is a significant chance of *self-selection bias* (Lavrakas, 2008). As another point of comparison, the final course evaluation for Iteration 1 of the course, conducted via the university EvaSys system, was extremely polarised. 15 respondents (44.1% of the total cohort) were split in two halves, where one half (8 students) highly praised the course, and the other half (7 students) gave it the lowest possible scores. In short, there was a sharp 'love it or hate it' split among the students who completed the final course evaluation. Such polarised self-selection bias is common and is known in the literature, e.g. see (Spooren et al., 2013). In the interviews, this 'love it or hate it' split was less apparent, and I therefore have grounds to believe that the distribution of students in the interview sample was more biased towards the students with more positive attitude, compared to the distribution of students in the final course evaluation. With this notice in mind, I proceed with the analysis of the interviews.

When analysing student' experience and attitude towards learning through video making, I identified the following three themes that appeared prominently in the interviews:

1. ***The idea vs the tool*** – it was clear that many students liked the idea of video making but did not like the provided tool (Bootlegger) because of the technical issues.
2. ***Learning/making styles*** – many preferred video-making to writing, some did not.

3. ***Levels of learning and additional skills*** – some interviewees demonstrated higher levels of learning through making, such as reflective learning, because the resulting videos needed to be instructional. They also acquired new skills.

Below I highlight the most interesting occurrences of these themes in the student responses.

The idea vs the tool

Overall, the students' attitude towards video creation was definitely positive. Even the students from the 'hate it' part of the cohort in the Iteration 1, said that the idea of making videos was good. In Iteration 2, the students were even more positive about this part of the coursework since they did not experience as many problems with Bootlegger as the students in Iteration 1. One student commented on the idea of video tutorial creation as follows:

> *"It gave us quite a lot of creative freedom to make something that was quite different. It was a different way of being assessed, of showing that you can teach someone else to do it rather than just write a bit of it and write an essay about it, which is what the other modules seemed to be mostly round, which was quite nice. It's something that I can actually show to someone else."*

Despite the positive attitude towards the idea itself, the students from all iterations of the course complained about various issues associated with the video making task. As per the theme ***the idea vs the tool***, the main issue, of course, was the tool, Bootlegger, especially during the Iteration 1. For example, one student said: *"when it came to Bootlegger, sometimes it felt like we were guinea-pigs. I felt that while the system shows promise and is a great idea, it is nowhere near suitable enough to base a coursework on"*. Only two student interviewees from Iteration 1 and one from Iteration 2 said that they did not like the emphasis on making videos as opposed to a more traditional emphasis on developing code, in particular, they noted that the coursework was: *"a good idea, but weighted too much"* and *"it seemed unfair that no credit was given for the actual Java code"*.

At the same time four student respondents from each of the Iteration 1 and 2 reflected positively on using Bootlegger, for example, one student specifically appreciated the collaborative aspect of the tool:

> *"I thought that was really great, since everyone had different videos particularly because not everyone knew exactly what to shoot, and so some people would have like a really great clip of what the outcome was, someone would do a really good*

like speech on how to set up the code, and so it all just pieced together really nicely."

Learning/making styles

Another theme that emerged from the interviews was ***learning/making styles****,* highlighting that video was perceived as different, specifically, more *visual*, format compared to the more traditional text. This is related to (i) the preferred learning style of the students, and also their preferred style of assessment; and (ii) the difference in the ease of presenting certain types of information, in particular, when working with Raspberry Pi kits, it was often much easier to illustrate something using video than to describe it using text. Here is how one interviewee explained why video was helpful for him: *"Visual examples is so much easier than having to explain it in words. Also, as the person who is watching the video later it is so much easier, from my experience".* Video coursework also was perceived to be more creative in comparison to other methods of traditional assessment. However, one student commented on an important aspect:

> *"I think videos are more-, it's more creative. It depends what you're good at really, some people might find a report really easy to do and some people find making a video really good and creative. So, it depends what your strengths and weaknesses are. I think I'm quite creative, so I quite enjoy doing the videos."*

Note that only about half of the study participants reported any previous experience in video making. A total of five students mentioned in the interviews that they were not comfortable in front of the camera, and since making headshots was not necessary, many students from all of the three studied cohorts chose not to include any headshots of themselves into their videos (while still often including their hands manipulating Raspberry Pi kits). One student shared her experience: *"The videos, they were different... and it was a bit weird at first recording the videos but after your first couple, I actually quite enjoyed it. So, personally I definitely prefer that to writing reports"*. Moreover, students reported that video assignment did not take them longer to do than a regular written report.

Wrapping up the ***learning/making styles*** theme, a strong majority (14 out of total 17 from Iteration 1 and 2) of interviewed students reported that they preferred video making to traditional forms of assessment, such as written reports and exams. They liked the idea of an alternative method of assessment for a Computer Science module. One student, for example, said: *"Videos were good, it's a different way. I have never done it before and it was good".*

Five interviewed students further acknowledged that a new type of coursework stimulated them to do more in terms of learning than a traditional report would do. One interviewee explained: *"It [video tutorial creation] did push me to do more features with the Pi that I hadn't done in the practicals"*.

Levels of learning and additional skills

Switching to the theme of ***levels of learning and additional skills***, the fact that the videos needed to be instructional added an additional level of thinking for the students. This was something unusual for the studied cohorts, for example, only 2 out of 17 student respondents in Iteration 3 reported that they had produced some materials for the learning of other students as part of another course. In the interviews and the survey, the students commented that the process of explaining the topic to another student forced them to re-evaluate their own understanding of the topic. One student elaborated:

> *"Well you had to think about how you're going to piece together this video to explain to another student. And I think putting yourself in the shoes of a teacher rather than a student gives you a deeper level of understanding. So, you have to know what you're talking about before you start speaking, you know! So, I thought that was good because it gave a sort of opportunity to really reinforce the learning."*

15 out of 17 (over 88%) of Iteration 3 survey respondents agreed that this coursework had helped them to learn the course material better, versus only 2 (i.e. 11.8%) who slightly disagreed with this statement. The students also were generally in favour of the idea of creating learning materials for someone else as part of their own learning: in the survey, 12 out 17 (i.e. 71%) of respondents agreed of strongly agreed with this statement. In addition, four of the interviewed students from Iterations 1 and 2 also agreed that students could sometimes explain new material to other students more effectively than the teacher. One interview respondent said: *"I really like this style. Learning by making is great. It helped me in the Ubicomp. And while teachers are essential, students can also be a great source of explaining things in a simpler way"*. Another respondent added: *"Other students have a better grasp of where your knowledge is currently up to, support from academics sometimes incorrectly assumes previous knowledge"*. This echoes back to the observation made by the instructors who also noticed how creation of an instructional video made them think differently about the material they were usually delivering via lectures.

Students also mentioned how video making helped them to develop additional skills, starting from expected skills, such as multimedia material creation: *"it allowed you to develop skills in audio and video recording and editing which probably a lot of students hadn't done before..."* and going to higher-level skills, such as communication: *"it helped me get how to teach, like how to present something in a way that could be useful"*. 11 out of 17 (i.e. 65%) of survey respondents said that they thought the skills they acquired through completing this part of assessment would be useful in their future career, see answers distribution in Figure 4:3 (Likert scale question: the Strongly Disagree option on the left, and the Strongly Agree option on the right).

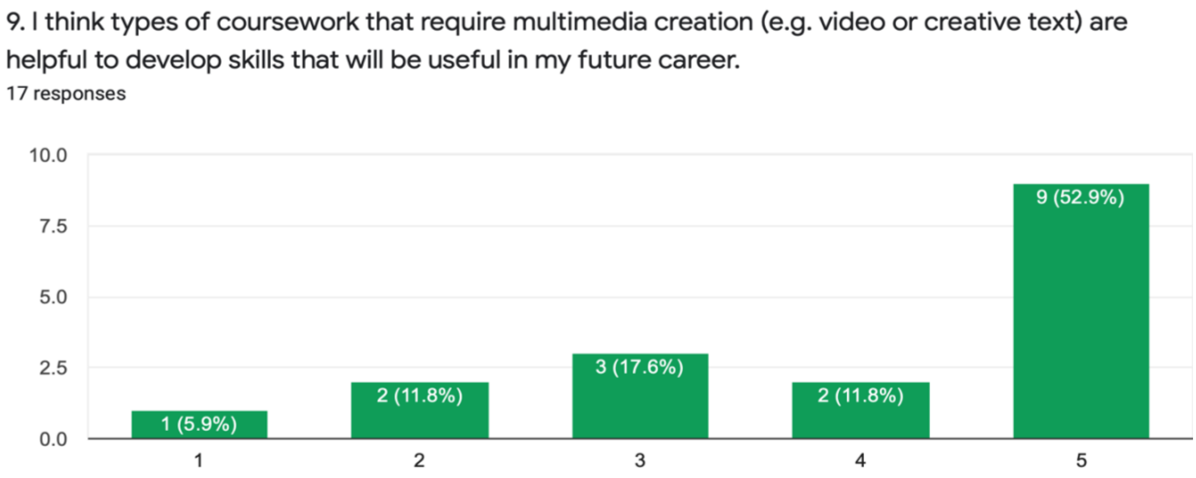

Figure 4:3 Distribution of answers on one of the survey questions.

Last but not least, 6 out 9 interviewees in Ubicomp Iteration 1, and 7 out of 8 in Iteration 2 mentioned that the video creation task also improved their subject learning. One of them explained: *"It did force me to gain an understanding of the task thoroughly so that I knew I had the knowledge to explain precisely what to do"*.

To summarise and answer the **RQ 2A**, the student experience of video creation was mainly positive. However, their attitude to the used tool was mixed due to the technical issues, which affected their coursework submissions. While not all of the students appreciated the value of video making in terms of deeper learning, many of them did find it very useful and enjoyable. Some reported an increase in motivation and the acquisition of additional skills through the process. Chapter 6 will specifically focus on the investigation of such acquisition of a few transferable skills, such as collaboration, fair use and attribution, and media literacy. These skills are listed among the essential 21st century skills that every modern student needs to acquire to be successful in their future career (Trilling & Fadel, 2012; Partnership for 21st

Century Learning, 2015). The analysis of the artefacts created by the students in Case Study A confirms that the students not only perceived the acquisition of these skills, but in fact demonstrated the development of these skills during the course – see Chapter 6 for more details.

Probing the wider student population

During Iteration 3 of Ubicomp, I decided to supplement the results obtained thus far by studying the attitude of a wider student community towards student content creation. To that end, I conducted a survey of STEM undergraduates at Newcastle University, going beyond the Ubicomp module and beyond the School of Computing. Among 121 participants, 74 students (i.e. 61%) studied Computing Science, while the rest came from different engineering programmes. The survey asked the students about their attitude towards learning through creation of instructional materials for other students.

The respondents said that they learned best by doing practical exercises (67%, n=81) and watching instructional videos (53%, n=64) – see Figure 4:4. This suggests that the two key ingredients of the SFC, namely, learning through making (i.e. practical creation of physical artefacts) and the Flipped Classroom approach (i.e. learning from videos rather than from traditional lectures), were the favourable methods of instruction of the survey participants. One student commented further on the question about learning preferences:

> *"Personally, I learn best through practical and coursework. Exams don't do much for me, as I find I cram information in and it doesn't really stick. Learning through creating or experimenting gives information a context through a practical application which is easier for me to remember in the long term."*

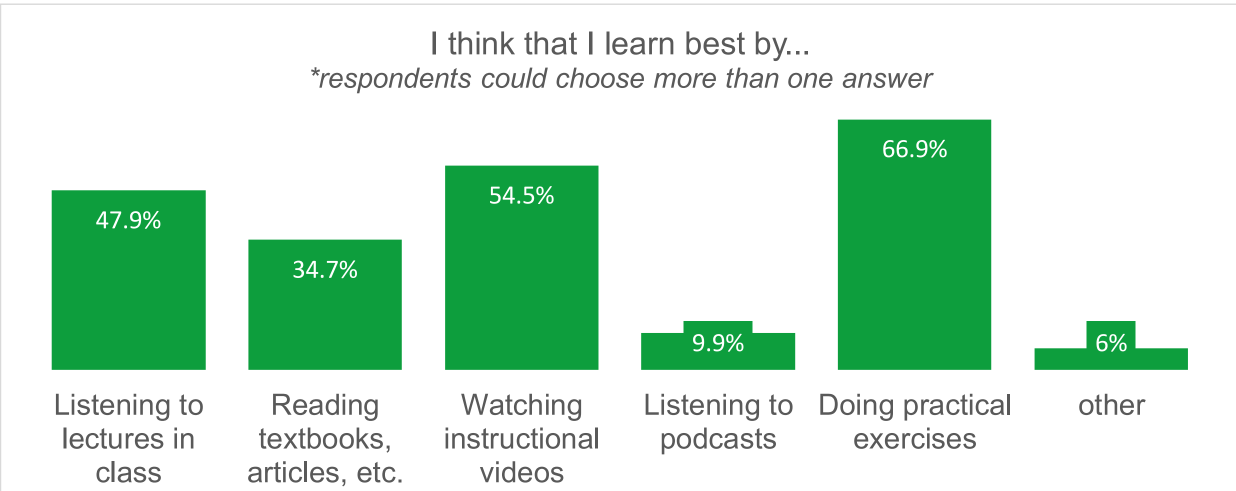

Figure 4:4. Learning preferences of STEM students.

Another respondent raised an important concern regarding an appropriate level of guidance for learning though making assessments. This is in part related to the complaints from some Ubicomp students, who did not fully understand the purpose of video-making and how exactly the videos were supposed to demonstrate their learning outcomes:

> *"In 'learning by making' there can often be very little guidance during projects, so project designs can receive a poor mark and the learning often only takes place after feedback is given, resulting in a mark that doesn't represent the student's understanding."*

On the other hand, when asked about the intentional creation of learning materials for someone else, only 37% (n=45) of students said that they liked the idea – see Figure 4:5. A slight majority of 39% (n=47) said they did not liked it, and 24% (n=29) were neutral. Somewhat paradoxically, as shown in Figure 4:6, most of the participants thought that this type of coursework would actually help them to learn the course material better: 53% agreed, and only 19% disagreed. Furthermore, 65% of respondents believed that this type of coursework would help them develop the skills necessary for their future careers. Finally, 85% (n=103) of the respondents agreed that students could sometimes explain parts of the course subjects to their fellow students more clearly than instructors (see Figure 4:7), and in general, the attitude towards using materials and resources produced by other students was more positive (57%) than negative (19%).

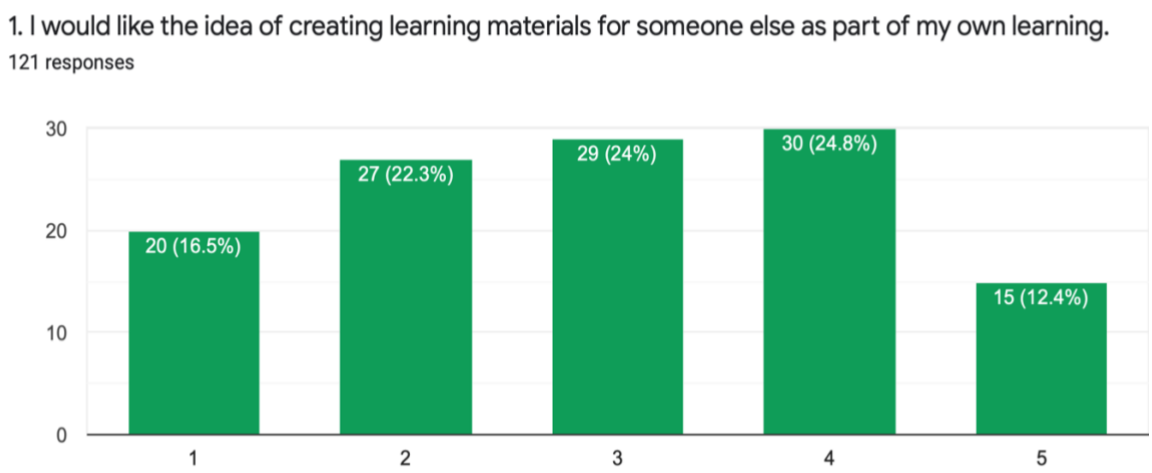

Figure 4:5 Opinion on creating learning materials for other students (Likert scale: the Strongly Disagree option is on the left, the Strongly Agree option is on the right).

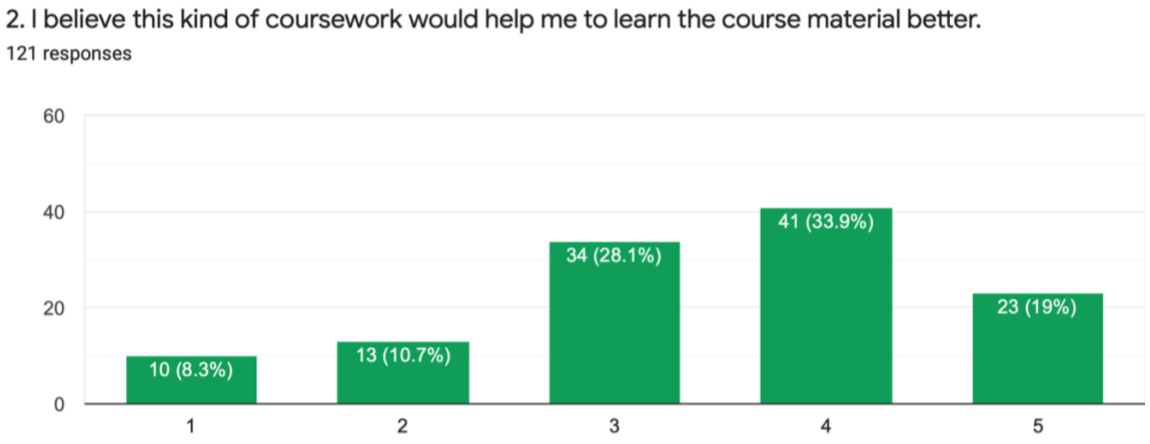

Figure 4:6 Opinion on whether creating learning materials for others helps the creators learn better (Likert scale: the Strongly Disagree option is on the left, the Strongly Agree option is on the right).

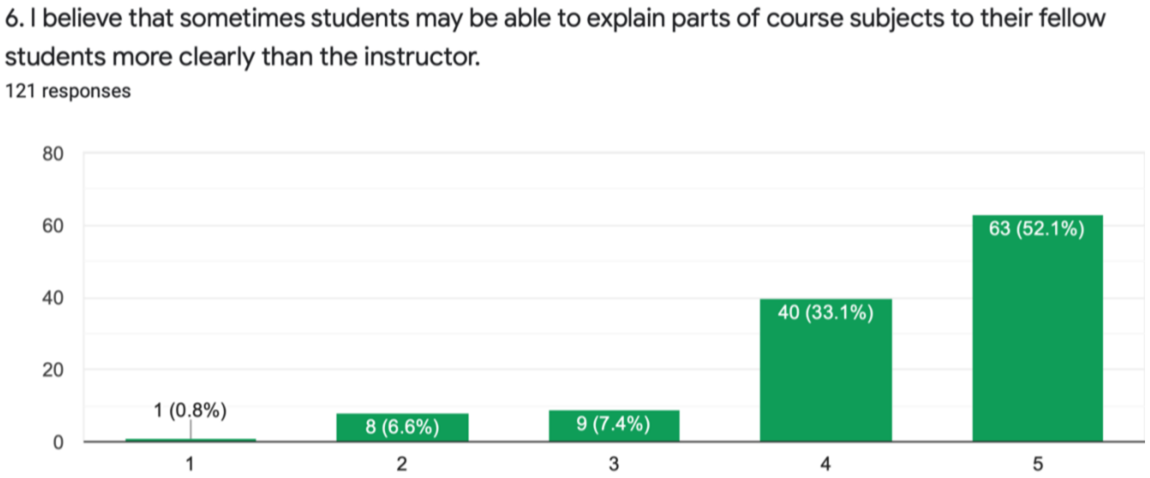

Figure 4:7 Opinion on whether students can sometimes be better explainers than instructors (Likert scale: the Strongly Disagree option is on the left, the Strongly Agree option is on the right).

The observed paradox suggests that instructors should work on explaining the students how they learn, helping them to think and reflect on their own learning. This should help the students internalise the fact that creating teaching materials for others is useful for them both as creators, and also as learners. If students understand better why instructors ask them to create materials for someone else, it would positively impact their attitude to the SFC settings.

4.3 Phase II: Reuse

In the first phase of Case Study A, we analysed attitudes and experiences of instructors and students during a Flipped Classroom course, where students were tasked with creating video artefacts suitable for use in the Distributed SFC model. The Phase II continues by investigating the reuse of the created artefacts, thereby completing the DSF picture. More specifically, we study the attitudes and experiences of instructors and students during a Flipped Classroom course, where the teaching video materials were created by other students.

4.3.1 Study Context

The Phase II of Case Study A was conducted as part of the project entitled "Development of a Physical Computing HE Toolbox for Engineering and Science Students", which is further referred to as the "Physical Computing" project, for brevity. See the Appendix C.1, "Physical Computing project fund application" for the project outline. The study was conducted as an inter-disciplinary and inter-departmental collaboration at Newcastle University.

As has already been noted, Raspberry Pi microcomputers (The Raspberry Pi Foundation, n.d.), multi-purpose microcontrollers, and 3D printing have great potential to engage students and provide innovative teaching of computer programming under constructivist pedagogical approach. This technology allows students to develop and test algorithms by interacting with the physical world through moving parts and sensors. The aim of the Physical Computing project was to develop a higher-education toolbox for teaching and learning of physical computing geared towards engineering and science students, and to deploy a series of cross-discipline activities to spread the usage of this toolbox in the classroom, student projects, and postgraduate research activities. This was achieved through cross-disciplinary collaboration between computer science and other science and engineering students. Activities comprised the development of learning and teaching materials as well as workshops, and were supplemented by prototyping projects for showcasing the potential of the technology.

a) Workshops

As part of the project activities, two workshops entitled "Python for Raspberry Pi – Sensors and Motion Control" were organised that were open for all STEM students at Newcastle University who wanted to learn how to use Raspberry Pi with sensors and motion control. The first of the two workshops was aimed at beginners, while the second was more advanced, building on the knowledge of the first workshop. The workshop participants learned how to develop programs using Python programming language (Python Software Foundation, n.d.) and use the Raspberry Pi General Purpose Input Output (GPIO) interface (The Raspberry Pi Foundation, n.d.) for building customised prototypes. See the Appendix C.1 for the briefs that were used as handouts for the workshop participants.

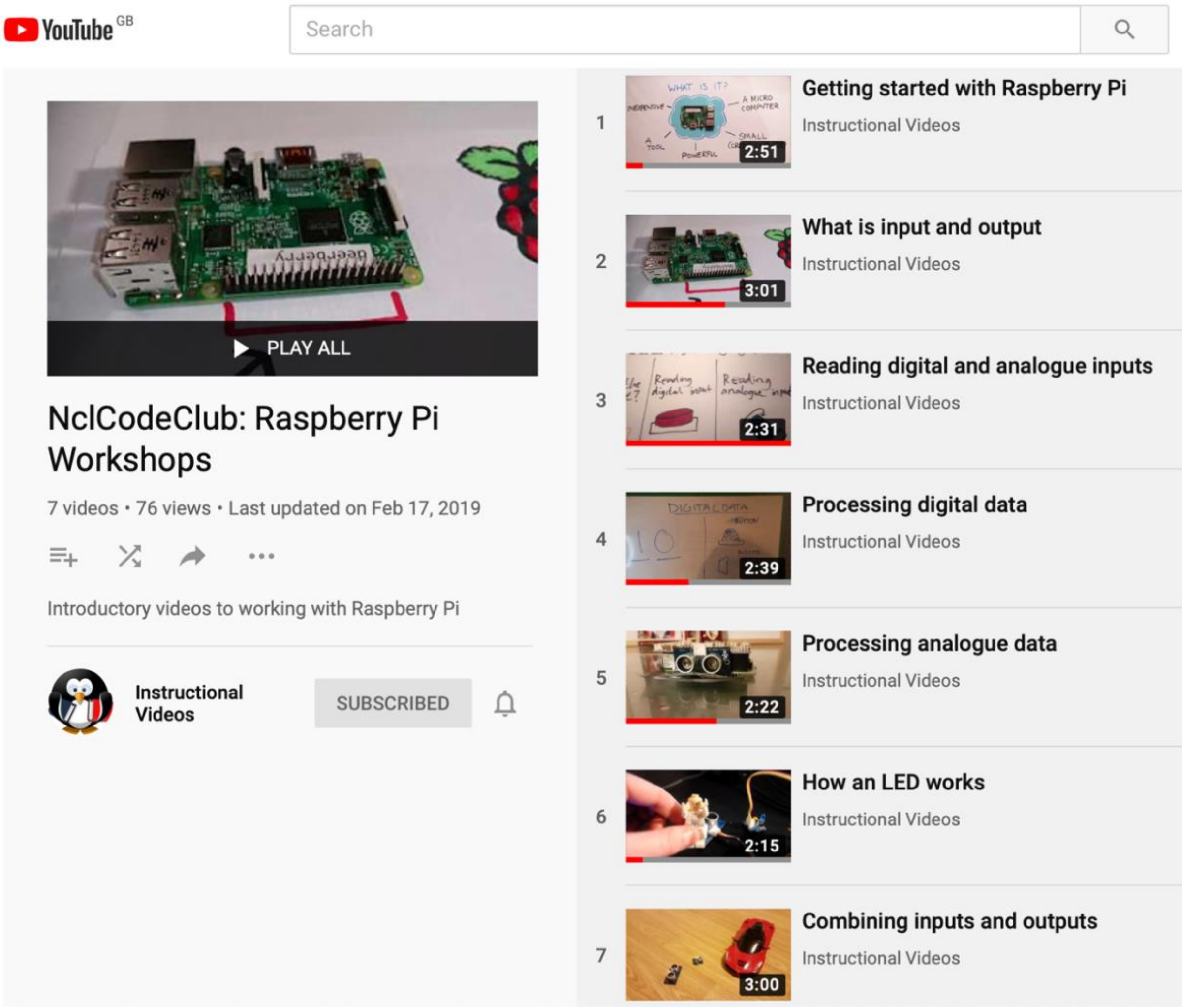

Figure 4:8. Screenshot of the YouTube playlist with introductory videos for working with Raspberry Pi.

A selection of video tutorials, seven in total, created by Ubicomp students (in the Phase I) was provided to the workshop participants in the Flipped Classroom format, prior to the workshops; see Figure 4:8 for a screenshot of the YouTube channel containing the selected videos. All authors of the selected videos were contacted beforehand to confirm their consent for these videos to be reused for teaching. These introductory videos aimed at helping the participants learn basic skills of working with Python and Raspberry Pi before coming to the workshops, thus saving the valuable instructor and peer contact time. The time at the workshop was then dedicated to applying the acquired skills in practical activities, for example, building a prototype of a bionic hand, as shown in Figure 4:9.

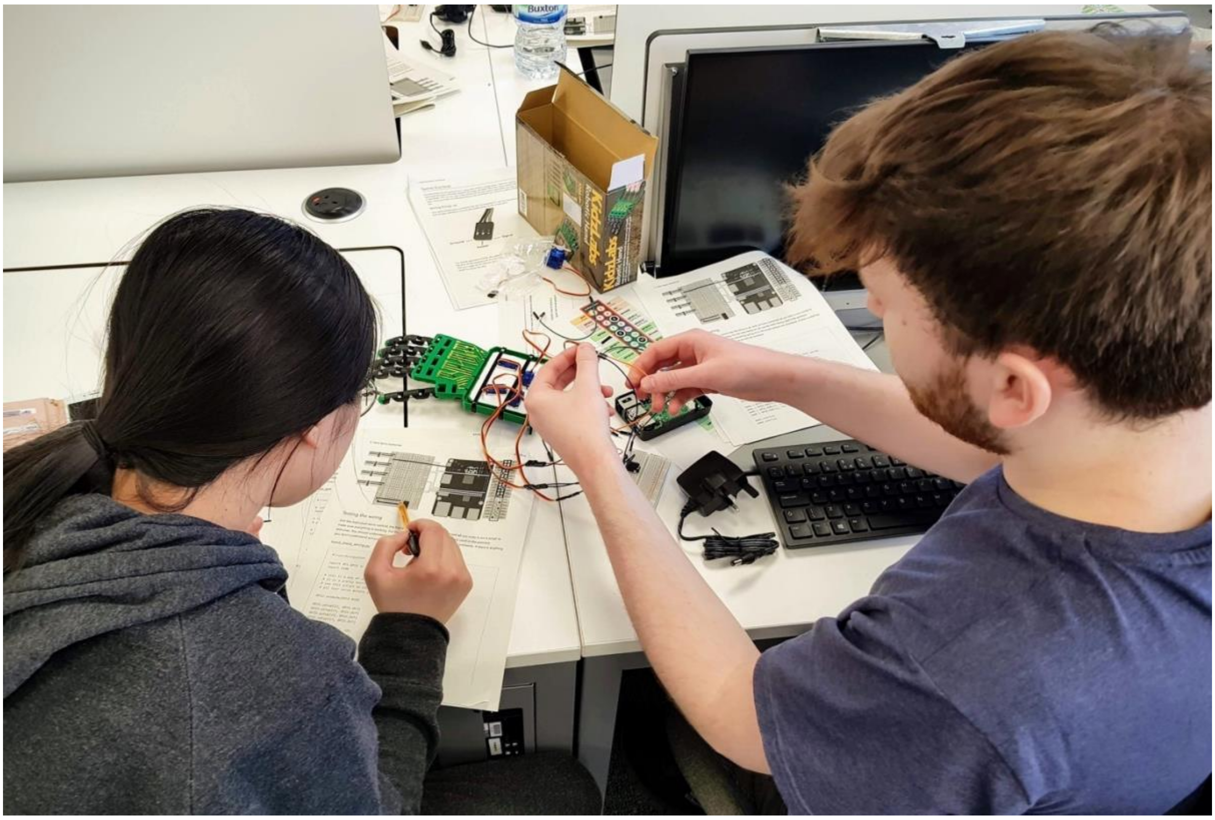

Figure 4:9. Students at the workshop, creating a bionic hand prototype.

4.3.2 Methods

This section introduces the research participants and provides a detailed description of the methods used for data collection and analysis in the Phase II of Case Study A. Data collection took place during the spring semester of 2018-2019 academic year.

Research participants

The first research participant was the leader of the “Physical Computing” project and the main instructor of the organised workshops. He was the one responsible for planning all teaching and learning activities for these workshops. At the time of the study, he was a Teaching Fellow in the School of Engineering, teaching Chemical Engineering undergraduates, supervising the final year design and research projects, as well as doing some postgraduate student supervision. He had been teaching at Newcastle University for 4 years and his classes were usually large, with 150-175 students, which motivated him to experiment with various tools for engagement for large classes.

The second group of participants were the students who took part in the Physical Computing project workshops. The workshops were very popular and after the first round of advertising more than 150 students applied to take part in the first workshop. There were only 15 available Physical Computing kits, so 35 students were confirmed with a place, to allow for small group collaboration. On the day of the workshop, 29 students showed up to take part. For the participation in the second workshop, the attendees of the first one were given priority, and 18 of them chose to participate. 2 more students who did not attend the first workshop were recruited, thus bringing the total number of participants in the second workshop to 20.

Out of those who participated in both workshops, 18 students volunteered to participate in pre- and post-workshop surveys. There was a good mix of students in terms of their level of studies: 13 undergraduate students of all levels, 4 PhD students, and 1 from the placement year, see Figure 4:10 for more details.

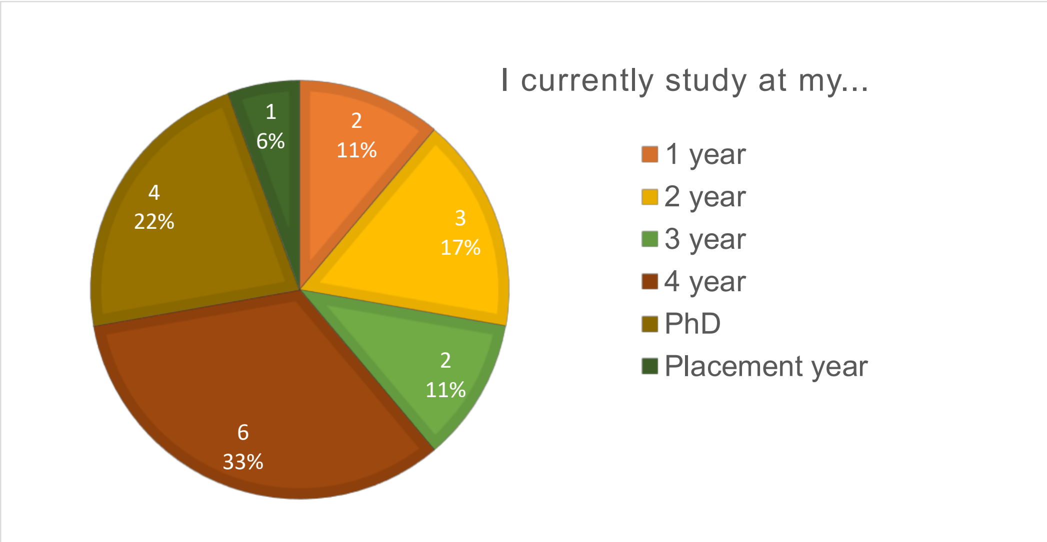

Figure 4:10. Survey participants by level of study.

The majority of the respondents were 22+ years old; 2 were in the 18-19 y.o. category, and 3 were in the 20-21 y.o. category. 14 of the respondents identified themselves as male, 4 – as female, and only one student chose the "prefer not to say" option. 7 out of 18 respondents were originally from the UK, 3 respondents were from Thailand, 2 respondents were from India and China, respectively, while Egypt, Italy, Spain, and Nigeria were each represented by 1 respondent. The respondents came from 5 different engineering degrees, with one more from a master programme in Automation and Control (see Figure 4:11).

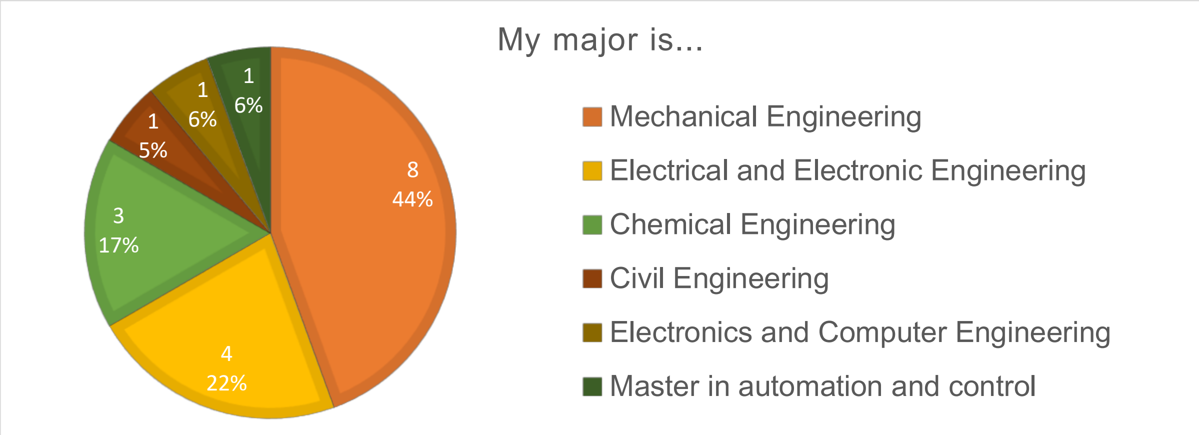

Figure 4:11. Survey participants by study specialisation.

The second sample of the workshop participants consisted of 8 volunteers who agreed to take part in the focus group after the first workshop and an additional student who volunteered to take part in the focus group after the second workshop. All 9 students are treated together in my analysis, because I was able to highlight the themes discussed in the first focus group and thus virtually "include" the extra participant into that earlier group conversation. 3 out 9 participants were female. Their age and degree subject representations were similar to that of the survey participants. See Appendix C.2 for the information sheet and consent form that were given to participants before the data collection.

Data collection and analysis

The data collection for Phase II included:

- Voluntary pre- and post-workshop survey questionnaires with workshop participants;
- An hour-long focus-group with workshop participants;
- A 40-minute semi-structured interview with the lead workshop instructor.

All students who participated in the first workshop were asked to fill in the pre-workshop questionnaire in the first 10 minutes of the session. We received 18 responses out of 29 participants (note that about 4 students came later, and furthermore, only 15 desktop machines were available as students had to work in groups of 1 to 3, which means that some of the respondents filled in the questionnaire on their own devices). The questionnaire asked the students to self-report their existing level of programming skills and confidence, as well as their motivation for coming to the workshop. See the list of questions in Appendix C.3.

The second survey was conducted in the last 15 minutes of the two workshop sessions. At the second session, we asked to complete the survey only those students who did not do it at the first session. 16 responses were collected at the first session and 2 more at the second one. This post-workshop questionnaire aimed at exploring the participants' experience at the workshop, their perceived improvement in understanding and implementation of computing concepts, as well as their opinions on the use of student generated videos. The full list of questions is available in Appendix C.3. These two questionnaires were intended to help answer the **RQ 2** by broadly evaluating the impact of the SFC on student learning. By asking the students to self-report their level of confidence, we aimed at understanding the perceived benefit of the workshops for their programming skills, and therefore see how effective SFC teaching could be in this particular setting. Moreover, the questions on students' attitudes to and experiences of learning from video materials produced by other students were contributing to answering the **RQ 2B**. The data from the surveys was analysed using descriptive statistics, e.g. determining the frequency distribution, the means, and 95% confidence intervals.

To complement the survey responses, I planned to conduct a focus group discussion with different groups of participants after each workshop session. However, in contrast to the first workshop, where we provided coffee/tea and cookies to the students, we could not provide any drinks and snacks during the second workshop session due to logistics issues. Because of that and the fact that the session lasted for 3 and a half hours in the afternoon, most of the second workshop participants felt hungry and could not stay for another hour to participate in the focus group. As a result, I only got 1 volunteer who agreed to stay and talk to me, which turned the focus group into a semi-structured interview format. For this interview I used the same schedule of questions that was used in the focus group; furthermore, I already preliminary analysed the focus group transcript and had several prominent themes coming out from that discussion in front of me while talking to the interviewee. As the resulting discussion remained very close thematically to the original focus group discussion, I decided to include the answers of the interviewee into the focus group answers analysis.

The qualitative data obtained during the focus group discussions was analysed inductively, by looking for the most important issues related to the students' attitudes and experiences. The goal of the analysis was to answer the **RQ 2** by focusing on learning in the Flipped Classroom format with a use of student-produced materials, and **RQ 2B** by specifically looking at the students' perception of student-produced videos as a teaching material.

The focus group protocol included the following questions (see the full list in Appendix C.3):

- Do you have any experience with the Flipped Classroom teaching & learning format?

- Did you watch the videos we asked you to watch before this workshop? (How many? Why?)
- What do you think of those videos in general?
- Do you think they helped you learn the content better or worse in comparison to other resources available during the workshop?
- Was it easy to learn from the video that other students have created?
- Would you prefer the same materials are made by your instructor?
- What do you think of the technical qualities of the videos?
- How would you improve them?
- Did you have any doubts with regards to the content delivered in these materials?

The last collected dataset was a 40-minute semi-structured interview with the lead workshop instructor. This interview aimed at understanding their experience of teaching in the Flipped Classroom format using student-produced materials. Therefore, the results contributed to answering the research questions **RQ 3** and **RQ 3A**. The data was analysed using a combination of deductive and inductive thematic analysis. I was interested in seeing if the same themes would appear as in the data collected from interviewing the Ubicomp instructors, e.g. workload and technical issues, but I was also open to see any new themes to emerge.

The questions used in the interview included the following (see the full list in Appendix C.3):

- Do you have any Flipped Classroom teaching experience?
- What do you think about Self-Flip in general?
- How easy or difficult was it for you to incorporate student-created materials into the teaching?
- What do you think these materials have added to your normal teaching?
- In your opinion what are the benefits for students to see and learn from the student-created materials?

4.3.3 Results

In this section I report the results of analysing the collected data, focusing on the instructor's and students' experience of and attitudes towards the SFC approach, particularly on the aspect of the reuse of student-produced teaching materials as part of the Physical Computing course.

a) Instructor experience

I start by investigating how the instructor prepared and run the Physical Computing course, and how his experience was affected by the use of student produced teaching materials, thereby addressing the research questions **RQ 3** and **RQ 3A**. The following themes were identified in the analysis of the instructor's interview:

1. ***Attitude towards SFC;***
2. ***Workload;***
3. ***Teaching experience;***
4. ***Technical issues.***

General ***attitude to SFC***: Despite having substantial previous teaching experience, the instructor admitted that he never used the Flipped Classroom approach before this course, thinking that the FC format might not be well-suited for the modules that he taught. He elaborated:

> *"I teach quite a lot of the foundation modules and I tend to find Flipped Classroom more valuable for the more advanced modules, where the foundation is built, so the students can have a self-direct learning. Although what you've done with the videos was slightly different, it was actually using the videos as foundation. So, that may now open a bit of ideas for other things."*

When asked about his general attitude towards the SFC, he said that there was definitely a place for such an approach in his practice, because in the courses he taught, the students were already involved in peer-learning by making presentations on various topics to each other. *"So, trying to get the students to create materials, I think it would be quite interesting, because the students are going to have to reflect about what they're going to put onto those materials"*. He specifically emphasised the idea that creation of materials suitable for others to learn from is beneficial to the authors: "*they have to think about and they have to apply the concepts and the things they learn, they also have to explain it to others, that means that they need to have a solid understanding"*.

Attitude to SFC: When asked if he thought the videos needed to look professional, the instructor made an interesting point that the students' quality expectations might be influenced by whether the videos were made by students or instructors:

"I think if you just reuse student videos, not necessarily. But if you deliver it as an instructor it has to come as a really good quality material. So, for example, if I embed a couple of 2-minute videos on a PowerPoint slide and show them through a lecture the students will be fine. But if I systematically do that, or if I embed longer videos, they won't be fine, they will want those materials to be created by the institution themselves. So, there has been some student feedback in the past in that sense."

Another encouraging remark was related to the students' confidence in their abilities to reproduce the results from the student produced videos:

"… sometimes the students do come with this approach 'oh this is rather difficult, I cannot make it' but perhaps if they do see other students making things, they may be more confident. So it's not the lecturer doing it, it's someone who is at their level of expertise. And some of them they may actually know the colleague from the previous year and that may make the students more confident, more relaxed about… Which in next turn is going to let them do a better job as well."

This was something that the students in both phases of Case Study A also agreed with.

Workload (the same theme as in Phase I): When asked how easy or difficult it was to incorporate the student produced videos into the workshop teaching, the instructor said that *"it was relatively straightforward"*. In part, this was because I, as a facilitator of the link between the Ubicomp course and the Physical Computing project, provided him with a ready-to-use library of 25 student produced videos. The videos were selected from the Ubicomp video tutorials in the "upper second" (65%) or higher category, for which I obtained an explicit permission to reuse from the authors. It is fair to say that I did a part of the instructor's work by preparing the library. He said to that:

"I think the critical thing is to build that pool and then from there you can shape as you need, depending on which class or which workshop or which topic you are delivering. So, if you build a library of resources, I think that's the biggest investment. Once the library is there then it's relatively straightforward."

Workload: Finally, despite the fact that the instructor needed to spend some time to select (from the library) the videos for using at the workshop, this load was much lighter compared to that of creating a similar set of videos from scratch.

Teaching experience: in line with the RQ 3A, this theme could be broken down to challeges and opportunities. The latter is addressed by the following comment of the instructor on the actual workshops and the Flipped Classroom format:

> *"I think it made the introduction of the workshops - so the theory part - it made it a bit lighter and I suppose that, for the students, would have made the workshop more interesting because I could deliver the content in 20 minutes rather than 40 minutes, I didn't have to explain some of the fundamentals that were on the videos."*

The instructor could save time at the workshop and use it for more practical activities: *"And then that also freed more time for the students to then do the practical section of the workshop rather than having spent more time on just going through slides."*

Teaching experience and ***technical issues***: In the discussion about the challenges he expected when implementing the SFC approach in his future teaching, he highlighted *"issues with copyright or the ethics of putting videos with students' images online"*; he also noted that *"the difficult bits tend to be the management of the submission because the video files tend to be rather large"*. Indeed, this issue came up in Phase I, where the instructors struggled with managing student video submissions.

Teaching experience (opportunity): Overall, the instructor was very much satisfied with the outcome of the workshops and strongly believed that the reuse of student produced videos contributed to it greatly:

> *"I think the students also enjoyed it, aside from the surveys we've done, there is quite a lot of informal feedback coming through emails afterwards and things like that and all the students emailing, they were really interested and they were really thankful about having the opportunity to take part in the workshop and they really wished good luck for the continuation of the project."*

Teaching experience (opportunity): He also highlighted another benefit of watching the introductory videos before the workshop: it catered for the variation in the programming skills of students attending the workshops, as they could select to watch the videos suitable for their current understanding of the key concepts.

In summary, the ongoing development of the Physical Computing Learning & Teaching Toolkit involves the integration of student produced videos and Physical Computing tools within computing-related modules in engineering disciplines. This will be followed by an assessment of student performance, and evaluation of the impact of Physical Computing and SFC approaches on student skills. Encouraged by the success of the first try of the SFC reported in this section, the team of academics involved in the Physical Computing project plans to develop future courses by including both phases of the SFC approach. The vision is that the same cohort of students would create multimedia learning materials (during the course) and make use of the materials developed by the previous student cohort (at the beginning of the course), hopefully leading to the testing of the ideal variant of Distributed Self-Flip and another validation of the benefits of the SFC.

One of the aspects that could be improved in future is finding new ways to efficiently search through previously created multimedia materials. Currently, this involves screening hundreds of videos in order to select the ones of acceptable quality, which proved to be a time-consuming process for the instructors.

To summarise the results presented in this section and answer the research questions **RQ 3** and **RQ 3A**, the instructor's experience of the reuse phase of the SFC was overwhelmingly positive. Specifically, it helped to (i) reduce the instructor's workload for the preparation of the course by reusing the existing library of student produced video materials; (ii) increase the proportion of the in-class time spent on active learning; (iii) cater for students with different levels of programming skills; (iv) increase the students' confidence in tackling the exercises thanks to seeing their peers succeeding at them in the videos. Encouraged by the opportunities, the instructing team is keen to continue applying the SFC approach when developing the Physical Computing teaching toolkit. The lead instructor also identified the following two main challenges: (i) the initial effort required to "bootstrap" an SFC-based course and prepare a library of student produced materials (once an initial pool of videos has been created, it is much easier to maintain and update it form one year to the next), and (ii) the lack of standard processes and technology for management of student produced video materials, which would allow for efficient and ethical collection of the materials, as well as their further curation, selection, categorisation, and, finally, reuse.

b) Student experience

Having analysed the experience of the teaching team in Phase II of Case Study A, this section covers experience of the students. Student perception was studied generally regarding the Self-Flipped Classroom, and specifically focusing on learning from student produced materials, thereby addressing the research question **RQ 2B**.

The inductive thematic analysis of the focus group data produced the following themes, which are presented below along with the data from the pre- and post-workshop surveys:

1. ***Flexibility;***
2. ***Effectiveness;***
3. ***Quality;***
4. ***Trust.***

Flexibility and Effectiveness

All of the students who attended the Physical Computing workshops reported that they watched the videos that were relevant to their prior level of knowledge. We monitored student activity using visitor statistics available on the YouTube channel that hosted the videos. The channel was private, and the 35 students who registered for the first workshop received access to the channel one week before the workshop. During that week, the channel had 27 unique visitors, which suggests that at least 77% of all students watched one tutorial or more. Bear in mind, however, that only 29 out of 35 registered students actually showed up for the workshop, so the percentage of students who came prepared is likely higher than 77%. No participants watched the videos during the workshop.

From the collected surveys and the focus group it became clear that the students were selective and watched only those videos that they thought would be useful for them. Indeed, some of the workshop participants were much more advanced in their programming abilities than others, and they could therefore safely skip some of the more basic videos. The ***flexibility*** of video instruction, especially in a form of a set of short tutorials, delivered to students in advance of in-class time, is demonstrated here at its best.

However, while student selectivity was confirmed by the individual view counts of the videos, there was one artefact of the YouTube platform that made the view count analysis less straightforward than it should have been. The introductory tutorial "Getting started with Raspberry Pi" was listed first in the playlist, and clicking on the playlist link caused YouTube to start playing the first video automatically, which explains more views recorded to the first video compared to the others.

The videos were ***effective*** at helping the students to prepare for the workshop, which was especially useful for the mixed-ability group of students attending this workshop. This was specifically highlighted by one of the focus group participants:

"It's a good idea because we're all going to be on different levels of knowledge. So, having the basics re-taught, you're like 'I remember that' or 'oh I haven't covered that yet'. But you can also skip ahead if you like 'I know this already,' but also it's good to get a refresher."

Students also commented on how watching the introductory videos before applying the new concepts in practice helped them to solidify their knowledge and improve their confidence. To quantify this, both the pre- and post-workshop surveys included a question about the students' confidence in their programming abilities (on the scale from 1 to 10), and the results showed a 48% increase ($p=0.05$) in confidence after completing the workshop. Furthermore, the students from non-computing disciplines became interested in integrating physical computing technologies into the regular modules of their programmes of study.

Quality and Trust

Regarding the theme of ***quality*** of the videos, students emphasised the ease and clarity of learning from them, and expressed their preference for videos made by other students, rather than videos made by instructors. For example, one of the students said:

"Well it sorts of shows the view of the student rather than the lecturer, and there's always a different view from a lecturer teaching something and a student actually learning it. A student will know what another student wants to know about it, which is better for a student to actually give it rather than a lecturer."

It was reassuring that the student responses tended towards the "slightly disagree" option for the statement that video technical flaws, such as camera shakiness or some image blurriness, had a negative impact on their learning. This indicated that students gave more importance to the content, message clarity and simplicity, rather than to the technical quality of videography. For example, one focus group participant commented:

"I think some videos were really well done… explaining why you're doing this, not just how to do this. It's that you have a problem and you're trying to solve it, walking through the problem and then the solution. Rather than just jumping in, 'what is this?', 'what is this used for?'"

On the other hand, students did note that some videos had less than prefect visual quality. While all of the focus group participants agreed that those technical flaws did not negatively impact their learning, one of students commented:

"I think it affects reliability. I trusted the videos because you sent us the links! But if somebody else was opening it and saw quality like this, he might be kind of sceptical, he might trust more something that has better quality."

This brings us to the theme of ***trust*** in the student-produced materials. The students placed a clear emphasis on the importance for the instructor to select and endorse the videos for reuse, so that they could be "trusted" to contain meaningful learning content, even if this increases the initial investment of the instructor's time.

A summary of the results for the quantitative survey questions is shown in Table 4:1. One can notice a contradiction in the student answers: in the survey, the students said that they prefer instructor-made videos, whereas the focus group participants said that they prefer student-made videos. One possible explanation is that the first reaction of a student to such a question is "the instructor must know the content better and have the ability to produce better teaching materials". However, when the same question was posed for a discussion during the focus group, the students themselves highlighted the important aspects presented above (the learner's point of view and the instructor's endorsement of the selected videos), which shifted their preference towards the student-produced videos. It is worth noting that the survey results were nearly borderline (3.3), which suggests that the students were generally undecided and that one could steer them towards acceptance of the idea of student-produced materials by an explanation and/or a discussion.

Table 4:1. The level of agreement with the statement, as answered by students that attended the SFC workshops. The level could be specified on the scale from 1 to 5, where 1 stood for "Totally disagree" and 5 stood for "Totally agree". The average level of 3.0 indicates a neutral response.

Statement	**Average level**
It was easy to learn from the videos	4.1±0.2
The video tutorials helped more than other resources	3.4±0.3
I would prefer videos made by an instructor	3.3±0.2
Video technical flaws had negative impact on learning	2.5±0.3
I had doubts about the content covered in the videos	1.9±0.2

To summarise the above results and contribute to answering the research question **RQ 2B**, we note that: (i) most of the students watched the videos before the workshop, selecting those which were appropriate to their prior level of knowledge; (ii) despite some noticeable technical flaws in the videos, the students commended their content and clarity of presentation; (iii) they trusted the student produced videos because they were selected and endorsed by the instructor; (iv) as a result of participating in the workshop, the students' confidence in their programming abilities had significantly increased and they showed interest for incorporating more elements of physical computing technology in their programmes of study, which shows that the Physical Computing workshops were successful.

4.4 Summary and Discussion of Results

This chapter presented Case Study A, dedicated to studying a variant of the Self-Flip, where the phases of *creation* and *reuse* were distributed between two different settings. The *creation* phase was studied during a Flipped Classroom course "Ubicomp". This part of my research was focused on exploring the FC format in general, analysing and documenting the experience of the teaching team and the students of Ubicomp over three academic years, as well as on evaluating the use of student content creation as part of assessed coursework. The second part of Case Study A was focused on the *reuse* phase of the Self-Flip. It was conducted during the two workshops for the Physical Computing project, where the Flipped Classroom format was enhanced by the reuse of student-produced materials.

By studying the two phases one at a time, I was able to separately answer the research questions related to the experience of: (i) instructors using student content creation in assessment, (ii) instructors using student-produced content for teaching other students, (iii) students learning by making video tutorials, and (iv) students learning from student-made video materials. I was also able to identify the SFC's opportunities, limitations and challenges, as well as implications for design of technology for supporting the Self-Flip.

4.4.1 Research Questions

Here I summarise my findings in relation to the relevant research questions.

RQ 2: *What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

Most of the students in Case Study A had no prior familiarity with the Flipped Classroom approach, or with the Self-Flip ideas of learning *from* student produced video materials and learning *by making* thereof. In the final course evaluation in Phase I, there was a 'love it or hate it' split among the students, which is common due to the self-selection bias (Spooren et al., 2013), and can also be explained by the technical issues with our collaborative video making tool. This 'love it or hate it' split was much less noticeable in the conducted student interviews, where most of the interviewees liked learning from online video lectures delivered before the in-class sessions, with only a minority saying that they preferred traditional lecture-based or text-based learning. The availability of text-based learning resources in addition to videos was particularly appreciated by the students who preferred learning from text.

As for learning by making videos, the attitude of all of the students in Phase I (that is, including the students from the 'hate it' part of the cohort) was positive; their only concern was the aforementioned issues with the video making tool. Students also appreciated the opportunity to apply fresh knowledge in practice by working with physical computing devices and creating their own ubiquitous computing systems, which also contributes to their general appreciation of the learning by making methodology.

In Phase II, most of the students watched at least one of the provided video tutorials before the Physical Computing workshops, consciously selecting the tutorials that were appropriate to their level of knowledge, which was important for the mixed-ability group of the workshop participants. The fact that the videos were produced by students (rather than instructors) was perceived in a strongly positive way: seeing their peers succeeding at the workshop exercises in the videos increased the students' confidence in tackling the exercises themselves.

RQ 2A: *What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*

The Ubicomp students' experience of video creation was mainly positive: most of the students found it very useful and enjoyable, even though not all of them appreciated the value of video making in terms of deeper learning. In addition to core subject learning, the students commented on gaining additional skills through the process of collaborative video creation, which prompted my further investigation on the acquisition of transferable 21st century skills, such as collaboration, fair use and attribution, and media literacy – the results of this investigation will be reported in Chapter 6.

When probing a wider population of STEM students at Newcastle University, I found that the respondents were generally unsure about the idea of creating learning materials for other students: the average response was leaning slightly towards the disapproval of this idea. However, most of the respondents agreed that such coursework would (i) help them to learn the course material better, (ii) help them develop the skills necessary for their future careers, and also (iii) that students could sometimes provide clearer explanations to their fellow students than instructors. Finally, the general attitude towards using materials and resources produced by other students was mostly positive.

The observed paradox (that students are unsure about the idea yet see only positives in it) suggests that it would be useful for the instructors to invest time in explaining the students how they learn, helping them to think and reflect on their own learning. This should help the students resolve the internal doubts and confusion about producing teaching materials for other students as part of their own learning.

RQ 2B: *What is the student acceptability and experience of learning from video materials created by other students?*

My investigation of this research question in Phase II found that the students had no hesitation in accepting video materials created by other students. This was confirmed both by the conducted student surveys and talking to the focus group participants, as well as indirectly by the instructor sharing the universally positive student feedback. In the focus group discussion, the students acknowledged that the provided video materials had noticeable technical flaws but they did not believe that that had any adverse effect on their teaching, and in fact praised the videos for their content and clarity. They also had no hesitation in trusting the content produced by other students; the fact that the teaching team selected and endorsed the videos was sufficient for the students to perceive the videos as trustworthy. Last but not least, the students remarked that seeing their peers explaining and working on physical computing projects in the videos boosted their confidence in tackling these projects themselves. The increase in their confidence in their programming ability was also confirmed by comparing the results of pre- and post-workshop surveys.

RQ 3: *What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

RQ 3A: *What opportunities and challenges do instructors face while implementing SFC into their teaching?*

In Phase I, the teaching team prepared all video materials for the Flipped Classroom by themselves, which was extremely time consuming, in part uncomfortable due to the lack of previous experience in front of the camera, and also hard to coordinate. Despite these challenges, all but one of the instructors believed that the FC format gave a better learning experience for the students by freeing in-class time for active learning, and also by forcing the instructors to rethink and restructure the content they usually deliver in-class to adapt it for shorter and more focused video lectures.

Another question studied during Phase I, was the experience of the instructing team in using student-produced videos for assessment and, as a consequence, producing a library of high-quality student-produced teaching materials. Here the instructors faced two challenges: technical issues with the collaborative video creation tool, and the novelty of this assessment method for the students, which led to issues of fairness and attribution, which I will further address in Chapter 6. On a positive side, and crucially for the SFC, many of the student-produced video materials were of high quality and suitable for reuse in future teaching. These materials demonstrated the students' good understanding of the taught subject, as well as the development of their video creation and story-telling skills.

In the subsequent Phase II, the instructor's experience of the reuse phase of the SFC was overwhelmingly positive. The created library of student-produced video materials significantly reduced the instructor's workload for the preparation of the Physical Computing workshops. It also catered for students with different levels of prior knowledge and freed time for in-class active learning. The lead instructor also noted that the lack of standard processes and technology for efficient and ethical collection and management of student produced video materials is an important issue that increases the amount of initial effort required to produce such a library.

4.4.2 Discussion

As can be seen from the above summary, particularly the part related to the research questions **RQ 3** and **RQ 3A**, most of the workload in the Distributed SFC settings falls on the teaching team that initiates the SFC process. Once an initial library of student produced materials is created, the task of reusing these materials is relatively straightforward and surprise-free for the instructors, as well as for the students. In Case Study A, the Ubicomp teaching team had to invest a lot of effort in preparing the FC materials by themselves, and, on top of that, take students through a non-traditional assessment method that involved the use of processes and tools unfamiliar to students, which inevitably led to unexpected issues and in the end was reflected in the 'love it or hate it' course evaluation feedback. The initial investment of effort by the Ubicomp teaching team eventually paid off during the Physical Computing workshops that were a success from the point of view of both the instructors and the students. I can therefore conclude that the main advantage of the SFC approach is not in the reduction the initial effort, but in making it possible for multiple teaching teams to benefit from this initial effort in their courses, and thus ease their transition to the FC and SFC teaching models.

It is worth noting that a Flipped Classroom does not necessarily need to include student content creation as part of the coursework. The Ubiquitous Computing module was unique in that the instructors attempted to include more than a single innovation at a time. Indeed, a pure Flipped Classroom approach might have provided a smother experience for them because many of the challenges (e.g. those related to the use of Bootlegger and its scalability issues) would have been avoided. Combining Flipped Classroom with student content creation required a coherent team effort of many people, and I am very grateful to them for persevering and successfully completing this endeavour.

The challenges encountered in Case Study A can be directed to the HCI and education communities. There is a need to develop better technology for collaborative video creation as part of assessment. In particular, the technology should: (i) cope with the high load during peak usage times when many students are shooting and uploading their video clips; (ii) eliminate the unnecessary complexity of submitting the final large video artefacts for assessment; (iii) streamline the process of obtaining consent from students to reuse their videos in future courses; and (iv) make it easier for various teaching teams to manage the resulting library of student produced video materials.

Other challenges, related to the lack of familiarity of students with video-based assessment, can be overcome by providing students with more background information on how to understand and be productive with new form of assessment, as well as give more frequent formative feedback during the course. It is also important to highlight the issues of fair use and attribution, and set clear boundaries between collaboration and plain copying, which will be further discussed in Chapter 6.

However, before focusing on the Chapter 6's investigation of transferable skills acquisition that could be supported though learning in various forms of Self-Flipped Classroom, I dedicate the following chapter to the presentation of second SFC variant – Enclosed Self-Flip. Thus Chapter 5 reports results of Case Study B that tested how both Self-Flip phases – creation and reuse - could be done within the same cohort of students during one semester.

Chapter 5. Enclosed Self-Flip (Case Study B)

This chapter presents Case Study B. The fieldwork in this case study was designed to investigate a variant of the Self-Flipped Classroom approach where the phases of *creation* and *reuse* occur within the same group of participants over a relatively short period of time (e.g. an academic term or a university semester). To emphasise the closed-world nature of this variant (as opposed to the Distributed Self-Flip), I refer to it as the Enclosed Self-Flip (ESF). In a typical ESF, a student cohort first creates SFC artefacts (e.g. during the first half of a semester) and then makes use of all or majority of the created artefacts for their learning (e.g. in the second half of the same semester).

Case Study B was conducted during the spring semester of 2017-2018 as part of a course called "Complex IT systems in large organisations" at Uppsala University in Sweden. The findings of this study have been published in a peer reviewed paper "Students as Prosumers: Learning from Peer-Produced Materials in a Computing Science Course", co-authored with Åsa Cajander and Mats Daniels (Vasilchenko, Cajander, et al., 2020).

5.1 Introduction

Traditional models of instruction are teacher-centred, viewing students as *consumers* of knowledge from their professors. Students are expected to synthesise facts, while assessments, such as exams and coursework, are designed to test how effectively the students can restate the information that they have passively ingested.

Today, modern technological advances, particularly Web 2.0, emphasise user content creation and collaboration. The trend of shifting the spotlight to users of technology leads to similar changes in more conservative aspects of our lives, such as education. Modern pedagogies focus on student-centred approaches; furthermore, students increasingly work in technology-supported environments and are tasked with assignments that require artefact creation. The students therefore gradually become *both producers and consumers* of knowledge as well as teaching & learning materials.

As discussed in the Literature Review (Chapter 2), numerous studies have demonstrated the many benefits of *students being creators* (e.g. Hardy et al., 2014; Wheeler et al., 2008). However, most often the created artefacts are short-lived; they only serve the purpose of assessing the students' work, and at best are used as examples from previous iterations of the course. Another instance of the student-centred pedagogical approach is *peer-assisted learning*

(Topping & Ehly, 1998), as outlined in Section 2.2.1. While both *student content creation* and *peer-learning* are well studied individually, very little has been written about the combination of the two approaches. Some work was done under the umbrella of Contributing Student Pedagogy (CSP) (Hamer et al., 2008), which has been covered in detail in Section 2.2.2. These studies have looked at theoretical and conceptual aspects of the pedagogy (Collis & Moonen, 2005; Cajander, Daniels, & McDermott, 2012), empirical quantitative evidence supporting its benefits (Denny, 2013), as well as teacher experiences with it (Falkner & Falkner, 2012). However, there is still insufficient literature on the *student perception of this pedagogy* and the work presented in this chapter is set out to address this gap.

Case Study B was conducted as part of an HCI course entitled "Complex IT systems in large organisations", where students acted as *prosumers*, that is, they produced a part of the course learning materials, and also consumed/learned from the parts that were created by their peers. The case study and this chapter address the research questions **RQ 2** and **RQ 3**, along with their sub-questions, by investigating the perceived impact of the Self-Flipped Classroom approach in the context of Enclosed SFC. More specifically, the focus was on the *student experience of and attitude towards creating multi-media materials* as part of compulsory coursework within a studied course (**RQ 2A**), as well as the *student acceptability and experience of learning from such materials* produced by their peers in the same cohort (**RQ 2B**). The case study also explored *attitudes and experiences of instructors who taught the course* (**RQ 3**), analysing the opportunities and challenges that Enclosed Self-Flip brings to their teaching practice (**RQ 3A**). The results of this case study contribute to the understanding of the overall perceived impact of the Self-Flipped Classroom approach.

5.2 Study Context

The studied course was a newly designed module introduced for the first time at Uppsala University in spring 2018. It was offered at the "Masters in Software and Information Technology" programme as a compulsory module for a specialisation called "Human, Machine and Society", which includes courses on HCI. The course was specifically designed to emphasise active and student-centred learning. The topic of the course – understanding the human side of the work with complex IT systems in big organisations in various contexts – was much more HCI oriented than the majority of other courses that the students had on offer for their degree, which is why I selected the course for my study.

The learning objectives of the course were to learn about various stages (e.g. development, procurement, implementation and maintenance) in the life cycle of complex IT systems in large organisations. The main learning outcomes of the course were: (i) the ability to describe potential challenges arising in connection with the development and introduction of IT systems in large organisations, as well as appropriate methods to address them; (ii) the ability to describe the challenges and problems that occur during procurement or development of systems intended for different user groups, and methods to deal with these; (iii) the ability to propose an appropriate solution for a given problem situation, as well as the ability to discuss advantages, disadvantages and applicability of the proposed solution. (See the course syllabus in Appendix D.1 for more details.)

The teaching materials for the course included reading of a popular novel on software engineering problems, "The Phoenix Project: A Novel About IT, DevOps, and Helping Your Business Win" (Kim et al., 2018) and several scientific papers in the area. The course delivery was in the Flipped Classroom style, based on seminars, and included active learning techniques (e.g. student discussions, debates and presentations) as well as artefact-creation exercises, such as interviewing field experts. It was mandatory to attend at least five out of seven seminar sessions to pass the course. The coursework was a combination of both individual and group assignments.

For the group project assignment, the students were tasked to conduct an interview with a selected field expert and, based on the received answers, create a rich but concise description of the expert's work. This description had to be in the form of a short instructional video and a text report which would be suitable for other students to learn from. Each group, comprising 3-4 students, selected a particular aspect of the IT system life cycle (e.g. development, procurement, implementation or maintenance), as well as a particular type of organisation where the system was in use (e.g. healthcare services, a commercial organisation, or public authority). Then, based on the selected combination (e.g. implementation & commercial organisation, or maintenance & healthcare), each group received contact details of a corresponding field expert, with whom the course teaching team had an agreement for participation in the study activity. In the beginning of the semester, the students received training by one of the instructors on how to conduct work place interviews and received support with preparation of their questions for the field experts.

The students also learned how to make instructional videos and were given access to equipment such as video cameras and microphones, if needed. One of the instructors' recommendations for the final videos was to avoid using video coverage of the actual interviewee. Instead, the students were encouraged to either re-enact the interview or present it in another format, synthesising the experts' answers into a short and clear informational artefact. According to the instructors' evaluation and the student feedback provided in the research interviews, the best videos in the course were made in the forms of interview re-enactment, a news report, or a TV talk show – see Figure 5:1 for screenshots from a TV talk show example. Some of the less popular videos were made using presentation slides with a voiceover recording, or a one-person narration – see Figure 5:2 for screenshots from a video with narrated slides example.

Figure 5:1. Screenshots from a video where students re-enacted an interview they conducted with a field expert in the format of a TV talk show.

Figure 5:2. Screenshots from a video where students present results of an interview they conducted with a field expert in the format of a narrated slide deck.

In the second part of the semester, after all of the student groups completed their projects, the videos and text reports were shared among all of the students in the class in order for them to learn about nuances of all the processes of IT system life cycles in all of the studied organisational contexts. In this way, each group project contributed to building of a bigger collective picture of various IT system life cycles. After watching the collectively created videos and reading the text reports, students took part in discussions during seminars using the techniques of *constructive controversy* (Johnson & Johnson, 1995) and *affinity diagram*

(Algozzine & Haselden, 2003) to stimulate peer learning. According to Daniels and Cajander (2010), the learning theory of constructive controversy posits that through discussions and controversies, where learners seek to reach a general agreement between conflicting information, ideas or opinions, they find a starting point to understanding complex issues and solving difficult problems. At the same time learners also discover new facts and develop critical thinking skills. The affinity diagram technique was used to support students in classifying and organising the information they found as the result of their group projects. Both of these techniques stimulated learning through productive sharing of the student group project results. In contrast to simple in-class presentations, the two techniques aimed at providing a better opportunity for students to actively learn from each other. The individual exam that the students had to do at the end of the course included the information presented in videos and the text reports produced by all of the groups.

Due to the nature of the course design (students working on different aspects of the studied topic), it was not possible to facilitate the same collaborative approach to artefact creation as in Case Study A. Therefore, while making the interview reports, the students worked in small groups without collaboration with the rest of the class. Students were also given freedom in choosing the video-making tools for their projects: no specific video-making application was introduced. Most of the groups chose to use smartphone cameras for their video making, although some used laptop cameras, screen recordings, or more advanced setups with digital single-lens reflex (DSLR) cameras.

5.3 Methods

5.3.1 Study Participants

The study involved two kinds of research participants: instructors and students.

The instructors were: (i) a course leader (referred to as 'CL' in the results) – an HCI professor, holding an esteemed title of *Distinguished University Teacher*, with extensive teaching experience who proposed and designed the course; and (ii) a teaching assistant (referred to as 'TA' in the results). The teaching assistant was a PhD student who had previously worked as a teaching assistant in other courses for several years prior to being involved in this course. Both of them agreed to give a research interview about their experiences of using the Self-Flipped Classroom techniques while teaching the studied course. See Appendix D.2 for the information sheet and the consent form that were given to them prior to the data collection for this study.

The students who took part in the course were at the Master level, specialising in "Human, Machine and Society" path of their degree programme. In total, 47 students took the course (the spring 2018 semester cohort). A self-selected sample of research interview participants comprised 12 students, i.e. 25,5% of the total study population, referred to as S1, S2, S3, etc. in the results. Two of the participants were female (S8 and S12), 3 of the participants were international students (S1, S2, and S10), while the rest (9) of the participants were from Sweden. The demographics of the sample was consistent with the overall demographics of the course cohort. See Appendix D.2 for the information sheet and the consent form that were given to the students prior to the interview.

5.3.2 Data Collection

The main data collection method for this case study was a semi-structured interview with open-ended questions (Braun & Clarke, 2013), conducted with the students and the course instructors in Uppsala after the end of the course. The interviews lasted from 30 to 45 minutes and were audio recorded with consent from each of the interviewees. The data collection was conducted with the following research questions in mind:

RQ 2: *What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

> ***RQ 2A:*** *What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*
>
> ***RQ 2B:*** *What is the student acceptability and experience of learning from video materials created by other students?*

RQ 3: *What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

> ***RQ 3A:*** *What opportunities and challenges do instructors face while implementing SFC into their teaching?*

More specifically, the interview schedule for the students was designed to address the **RQ 2, RQ 2A** and **RQ 2B**. The interviews were based on the set of questions listed below:

1. *What is your overall impression of the "Complex IT systems in large organisations" course?*
2. *Was it easy to learn from the materials (video, etc.) that other students had created?*

3. *Would you prefer if the materials were made by your instructors?*
4. *What did you like about the materials?*
5. *Was there anything you disliked about the materials?*
6. *Do you think the videos helped you learn the content better or worse in comparison to other resources available during the course?*
7. *What do you think of the technical qualities of the materials?*
8. *How would you improve them?*
9. *Do you think your work was better than the work of others?*
10. *Did you have any doubts with regards to the content delivered in these student-made materials?*

The interview schedule for the instructors was designed with the **RQ 3** and **RQ 3A** in mind. It was based on the following questions:

1. *How easy or difficult was it for you to incorporate student-produced materials into the teaching?*
2. *What do you think these materials have added to your normal teaching?*
3. *In your opinion what are the benefits for students to watch and learn from the student-produced materials?*
4. *How do you evaluate the technical quality of the student-produced materials (especially videos) in this course?*
5. *How do you compare your planning of the course curriculum with the student-produced materials to your normal teaching?*
6. *Are you satisfied with the course outcomes? How do you think the use of student-produced material impacted the results?*
7. *What would you do differently next time?*

The complete list of questions that were used as a base for these semi-structured interviews is provided in the Appendix D.3.

In addition to the interviews, I had access to the course syllabus (outlined in the Study Context, Section 5.2, and presented in full in Appendix D.1), student-produced videos, and the final course evaluation results. The final course evaluation was conducted by the course instructors in the form of a survey with 10 multiple-choice questions, 9 open-ended questions and an option to leave additional comments and suggestions. 30% of the students (14 out of 47) completed the survey. Some of the questions in the evaluation survey were directly relevant to the research questions of this study, such as student satisfaction of the course, as well as their attitude towards creating and reusing the videos and text reports. I therefore present student answers from the survey along with the interview results below.

All data collection and analysis for this case study was in line with Uppsala University ethical guidelines and did not require any further approval in addition to the one obtained from the ethical committee of Newcastle University.

5.3.3 Data Analysis

All of the interview audio recordings were transcribed and subsequently thematically analysed using the inductive approach (Braun & Clarke, 2006; Thomas, 2006) as previously summarised in Chapter 3.

The next section discusses the key findings from the analysis which are organised by the research questions covered in this case study. In addition, several common themes relevant to the research questions are identified and discussed. The findings represent the points of view of both the students and the course instructors.

5.4 Results

The inductive thematic analysis of the student interview data yielded 16 themes associated with the students' attitudes and experiences of the teaching and learning in the course. See a summary of the results in *Table 5:1. Summary of the most representative attitudes and experiences that the students expressed in the* interviews, organised by the identified themes (**T1** through **T16**). The summary shows the most common answers the students gave in their interviews as well as conflicting opinions, usually expressed only by one or two of the respondents. It is worth noting that the number of respondents in the table does not always add up to 12, which was the total number of the interview participants. This is due to the fact that the interviews were semi-structured, and therefore not all of the topics were discussed in every single interview. Furthermore, some of the student responses could not be sharply categorised as "agree" or "disagree", as will be further clarified as part of the research questions discussion.

Table 5:1. Summary of the most representative attitudes and experiences that the students expressed in the interviews

Themes: Attitude / Experiences	**Representative Quotes**	**Student replies**	
		Agree	**Disagree**
T1: Overall impression of the course was positive	*S3: "It was a good experience. I actually felt like it gave me much more than I expected, at the beginning."* *S9: "Conceptually it has a lot of good ideas, but the execution was bad, because it was very little to actually do."*	S1; S2; S3; S4; S5; S6; S7; S8; S10; S11; S12	S9
T2: The course was different from any other courses	*S1: "It was very different from other courses we've had so far. I don't think people in the class were used to having this way of learning."* *S4: "The course was interesting and very different: it didn't involve any coding"*	S1; S2; S6; S8; S7; S9; S10; S11	
T3: The coursework was good	*S2: "The video made by students, it was something new to me and I would say it's a good initiative."* *S5: "The interviews were really good to learn how to interview at workplace, because in most situations you need to interview in some way. But video making itself, maybe not that important, I don't think I will ever use it."* *S7: "First we had to learn how to do the interviews… then it was just fun, to make the actual video. We had so much laughter while making it!"*	S1; S2; S4; S5; S7; S8; S10; S11; S12	S9
T4: It was easy to make the video	*S2: "No, it was hard! ((laughs)) Like to make a 30 minutes interview, then to put all the points together, to make people understand within the five-minute video, that was a bit hard. But yeah, I think it was fun."* *S6: "I think, we did our video in about half an hour. It was too simple, it didn't feel like university level of assignment."*	S1; S6; S7; S8; S10; S11; S12	S2; S3
T5: Had previous experience in video-making	*S7: "No, I've never made a video before! Certainly nothing at university level, this was the first one."* *S8: "Yeah, I had some experience with video editing in my spare time, we also had a little project with a simple video making at school."*	S8; S11	S3; S4; S5; S6; S7; S10; S12

T6: Video making was helpful to learn the course material	*S11: "Making our own video added learning value. While selecting quotes from the interviewee, re-enacting and recording them, editing and polishing the video, there was a lot of material repetition… It was like over and over again, so, some stuff really stuck with me."* *S9: "The video itself was pointless, as it directly mirrored the text report."*	S1, S7; S10; S11	S3; S6; S9
T7: The time spent on video-making was worthwhile	*S7: "Personally, if I'm having fun with something, I don't really keep track of how much time I put into it. But for that video it wasn't too much… I'd say it wasn't too time consuming, for the credits, for the course, I'd say that was completely fine."* *S11: "Well, I mean, yeah, it helped me learn the material. But when I learned all material well enough there was still some filmmaking left to do so. So, it's important to balance how much time is going to actual learning of the material versus how much time is used to make the video."*	S1; S7; S10	S3; S4; S11; S12
T8: Video making skills are important for future career	*S6: "It was the first time during the entire education where we had to do an assessment like being videotaped and that's something that probably will happen at some point in everyone's working life. Later on, you hold a presentation and then the presentation is videotaped for the sake of the company, so other people can learn."* *S11: "I picture myself as a programmer in the future and I don't think I will be making movies, but maybe if you choose some other paths than that could be useful."*	S6; S10 (maybe)	S3; S5; S9; S11
T9: Feeling satisfaction and pride for the created material	*S11: "I think we had one of the best videos because we put some time into it. It wasn't hard and we really enjoy doing it."* *S4: "We were about average in both the content and technically."* *S10: "Ours was a normal boring video, but the other people did it pretty good and it was funny. Looking at some of other videos I thought 'Ah, we should have done it that way'."*	S1; S2; S7; S8; S9; S11; S12	S3; S4; S5, S6; S10
T10: It is better to learn from videos than from text reports	*S9: "A video is longer to watch and harder to navigate than reading a text report."* *S10: "Of course, it's easier to learn from video, I'm talking about myself, I'm more visual, I don't like reading."*	S1; S2; S4; S10; S12	S3; S9; S11

	S11: "I liked making the video, but I prefer to learn from texts." *S5: "Well to get an overview on the whole subject, I think the videos are better, but to really learn the details it's better to read".*		
T11: It was hard to learn from student-produced videos	*S1: "This was pretty hard from some videos because it felt like some groups hadn't grasped the purpose of the video, that the videos were actually supposed to teach something."* *S12: "For me, I think it was the video that gave more than the reports. I enjoyed watching the good ones and it was easy to learn from funny films."*	(all talk about only a few videos): S1; S3; S5; S7; S11	S4; S6; S10; S12
T12: Video technical flaws had negative impact on learning	*S3: "One video was shot outside in the woods, and there was wind that interfered with the audio. So, I had a hard time focussing on the details in that video."* *S8: "I think most people actually managed to cover the part of being able to be heard and being able to be seen. Most people had a pretty decent camera so nothing really looked too blurry, everything seemed to be in sync with the sound. So, I think in general it was fine in that technical way."*	S1; S3; S11 (one video)	S2; S4; S5; S6; S8; S9; S10; S12
T13: I would prefer the videos were made by instructor	*S5: "It's beneficial to make the video yourself, but the instructor's made-videos would be more efficient to learn the things better."* *S4: "It would not make sense at all – the big part of the learning experience was to do the videos ourselves."*	S1; S3; S5; S9	S2; S4; S6; S7; S8; S10; S12
T14: Had doubts about the content covered in videos and text reports	*S8: "There was just like one video that made us question their focus (on being a leader rather than being a part of an agile method structure). But otherwise, at that point I just blindly trusted the videos, mostly. Which I don't know, afterwards, if that's a good idea or not, but at the same time, like if our instructor looked at them as well, I think, that hopefully they were pretty correct!"* *S9: "I know they talk about critical thinking and all that, but in general you accept everything you are getting in the university."*	S3 *(in one video)*; S5 *(inter-pretation of an opinion)*; S6	S1; S2; S4; S7; S8; S9; S10; S11; S12

T15: Appreciation of peer-learning	*S4: "I liked the fact that each group covered a piece of a matrix. It was interesting to see how our work fits into the matrix, also was interesting to see what was different and what was similar in different organisational contexts."* *S5: "One of the problems with this method of learning, is that the students are collecting and presenting the information. If they miss something then the rest of the class will miss it as well. But it's a good way to collect a lot of information."*	S1; S2; S3; S4; S6; S7; S8; S11	S5
T16: It was great to learn from materials produced by classmates	*S2: "It was such a diversity of the videos, I mean, it was fun watching them, but it was easier to learn from them too. I wanted to see every single video to look at my classmate faces and their work and everything."* *S8: "It was a good idea to actually watch other people talking because otherwise it's going to be forever the same person telling you the same stuff and everything is just going to blend together. When we looked at so many different videos, they were made by different persons from my class and since I know these people I actually have attention to who said what. I remember 'that guy said this, this girl said that'. I think it helped me to remember more information."*	S1; S2; S4; S6; S7; S8; S10; S11(more from reports); S12	

In the next subsection, I will discuss Table 5:1 in detail and, by adding the course evaluation results to the student interviews, I will answer the **RQ 2** and its sub-questions, in order.

5.4.1 RQ 2

Themes **T1**, **T2** and **T3**, presented in the Table 5:1 above, illustrate the general **attitude of the students** to the Self-Flipped teaching and learning methods used in the studied course (the first part of the **RQ 2**). 11 out of 12 interview respondents said that their overall impression of the course and its delivery methods was positive (**T1**). For example, S7 said: *"It was a good course, it was a good experience, it was very enjoyable!"*; and S5 added: *"I think it's a really good way to learn, but it's harder to make it work really good. I'm not saying it worked bad in this course, but I think they could make it a lot better"*. The most negative opinion came from S9, who criticised the course for not being challenging enough and not providing enough of teaching material: *"More material needs to be on the master level course. This one was like a two-weeks work"*. Still he said that conceptually the course had many good ideas, e.g. group projects covering different topics and the peer-learning through the exchange of the results of those projects (student-produced materials). S8, despite being generally very positive about the course, also commented that the course workload was not balanced and felt lightweight after the first half of the course.

The course evaluation survey, however, provided a different balance of the student responses, where 57% (8 out of 14) of survey respondents were not satisfied with the course. Moreover, both the course leader and the teaching assistant mentioned in their interviews that they had a strong impression that the students in general had a "love it or hate it" attitude towards the course. These facts suggest that more students with positive attitude about the course chose to participate in the research interview, which may have led to a not fully representative sample of the whole cohort.

8 out of 12 interview respondents said that the course was completely different from everything else they had before in their studies (**T2**). Some students felt sceptical about the course at the beginning, as they did not anticipate that a course which did not teach technical skills (such as programming or mathematics) could be useful for them. However, as the course continued, the students found it to be interesting and even better than they expected. S3 noted:

> *"I prefer courses that are specifically aimed at improving my technical knowledge. Like a course in algorithms, or mathematics or specific programming courses. So, every time I see a mandatory course that's a little less technical and more towards the social sciences, if you could say that, I get kind of sceptical… but I actually felt like this course gave me much more than I expected, at the beginning."*

Indeed, the initial reaction of a majority of the students who signed up for this compulsory course was a surprise: *"it was something completely different – no coding"*, said S4. He added that he thought that the course name suggested learning how to build a complex IT system, not how to work in a team who deals with it. Everyone else commented on how different it felt to study such a 'not technical and not hands-on topic', which students were not prepared for. An absolute majority of interview participants said that they expected to learn how to code or to solve math problems in a Master's level IT and software engineering course. One student (S6) elaborated:

> *"We are doing so many hands-on coding projects and everything is pen and paper or typing code on your keyboard and then all of a sudden you get a course that has no programming. And then you are in the mindset that everything needs to be programming-based, every project needs to be something that you develop. And for four years of education you haven't got anything about how to work in a group!*

You've done a bunch of group projects where you had to cooperate just by feeling and just by however you as a person work but you have never been educated or studied the subject of group work or how to work together. And then all of a sudden, this course comes up and you're not really prepared for the subject… this course is very different, and I think people don't really realise that that's a good thing."

Another student (S1) also noted: *"I don't think people in the class were used to having this way of learning".* The whole approach to the student-centred learning was unfamiliar to them. S3 noted that the teaching and learning approach used in this course would not work for any subject but could be a good fit for HCI courses. Specifically, he said:

> *"I would prefer to have more courses with this method but it should work together with the course subject. So, perhaps for a programming course this wouldn't be very good, because you have to sit there by yourself and actually work with it more and more hands-on. But for other courses that are more theoretical like for this course or maybe for other human-computer interaction courses. I think this would be really really good."*

Regarding student attitude towards the coursework assignments they had for this course **(T3)**, the overall opinion was positive, with 9 out of 12 interview respondents saying that they generally liked the coursework. However, according to both the interview responses and the course evaluation, the students saw more value in doing the interviews and writing the report parts of the assignment. The attitude towards the video making part, however, was quite mixed. S6 explained: *"I learned a lot by doing the interview and being there. We did the interview at their workplace and walking through their corridors and going into their meeting rooms and feeling the atmosphere of being at a real workplace - that gave me a lot".* S5 added: *"The interviews were really good to learn how to interview at workplace, because in most situations you need to interview in some way. But video making itself, maybe not that important, I don't think I will ever use it".* Also, 7 out of 14 course evaluation survey respondents felt that the video making assignment *"was not at its place in this particular course"*; however, 8 out 14 survey respondents admitted that it *"was a fun experience".*

A possible explanation for the attitude is that, while creating their videos, some students did not understand how the video part should be different from the text part of their report, and that, in fact, they should complement each other, not duplicate. As S9 commented: *"The video itself* *was pointless, as it directly mirrored the text report."* On the contrary, S2 said: *"The video made by students was something new to me and I would say it's a good initiative".* 5 other students affirmed in the interview that they understood the value of making and learning from two types of instructional materials. S7 said that *"the reports with the video worked excellently"* by complementing each other. I will return to the comparison of student attitudes to video and text reports in the following sections while discussing student experiences of creating and using these types of the Self-Flip materials.

In summary, the above findings suggest that students tend to have more positive attitude towards the Self-Flipped teaching and learning when they fully understand the purpose of each part of the innovative pedagogy. The students who did not grasp the purpose of the video-making part of the learning activity and the course assessment (as another way to present the learning outcomes) did not appreciate the peer-produced videos as a complementary teaching resource, and also had a better attitude to what was customary for them already (e.g. text reports).

a) RQ 2A

The **RQ 2A**, specifically the aspect of **acceptability and experiences of creating multi-media materials**, is covered by the themes **T4** through **T9** in the interview data analysis, as outlined in Table 5:1 above.

7 out of 12 interview respondents said that they never tried to create a video before this course, although S4 noted: *"I think there was at least someone in every group who had experimented with video making before"* (**T5)**. As a counterexample, S10 said that nobody from his group knew how to make videos, so he *"had to learn it from scratch for this course. It took one day maximum, and it might be useful in future"* (**T7**). Furthermore, 7 of the interview participants commented that it was *easy* for their groups to create the video part of their project report and only 2 participants said the opposite (**T4**).

On reflection, different students meant different things by calling the task "easy": for some, it meant not challenging and quick to do; for others, it meant enjoyable and appropriate for the course credit, even if it required additional time and effort. For example, S6, who said that his group spent only about 30 minutes to make the video, also mentioned that for him it *"was too simple, it didn't feel like university level of assignment"* – their group's video in fact was one of the most criticised by everyone else who participated in the interviews. Their video was easy to identify, as it was one of three videos that were shot outside, with a sole speaker delivering a monologue or monotonously responding to a series of questions. The peer criticism was directed not only at technical qualities or inadequate filming environment (e.g. wind interfering with the voice of the speaker), but also at the style and content of the message; being just a long monologue, the video was not easy to follow and understand for most of the students. Even S10, who was in the same group with S6, described their video as "*boring".*

In contrast, S7, whose video was generally referred to as the best example among the cohort, spent significantly more time on their video. This video was well made, had a very playful manner with good acting, many jokes, 'Easter eggs' (i.e. hidden messages), and, according to the majority of students, a clear message regarding the course content. S7 said they have spent *"some time"* making it:

> *"First, we identified the core content that we had to deliver, and then we tried to give it some form of good production around it, and then tried to have a little fun with it, so that you can actually enjoy the video at the same time as you're actually learning what we're telling you."*

S7 also added that because he and his group very much enjoyed their time making the video, they did not feel the workload was heavy, they felt it was completely adequate for this course (**T7**). Similarly, S1 commented: *"Although, the video creating added like a few hours for each person in the course, with the video editing and so forth, I think it was definitely worth it."* Other 5 interview participants, who, perhaps, were not as confident with video editing skills, complained that the finishing of the video took a bit too long. S8 explained: *"maybe some people will want to have a lot of time to do these movies, but I think a lot of them will not, because they don't feel like this is a part of our learning experience really".* So, those 5 students thought that they were spending time on unnecessary work and learning a useless skill.

One of the themes that emerged during the interviews was that the video making felt like an odd thing to do for students because many of them believed that a software engineer or an IT specialist does not have to know how to work with multimedia (**T8**). For instance, S11 stated: *"I picture myself as a programmer in the future and I don't think I will be making movies, but maybe if you choose some other paths than that could be useful".* In total, 4 interview participants were convinced that video making skills were not at all important for their future careers, while 2 participants had the opposite opinion.

One of the most relevant aspects for the Self-Flipped Classroom approach was evaluating whether the students felt like they learned the course material while creating their videos for the course (**T6**). 4 interview participants explicitly stated that they believed that video making helped them to learn. For example, S1 explained:

> *"I think that making your video of your own subject was very good because then you had to take all this everything you learn, put everything down, and then you have to like process it and make it understandable for someone who hasn't seen it before. And, at least, I learned a lot from just processing our own material."*

A similar opinion came from S11, who said: *"While selecting quotes from the interviewee, re-enacting and recording them, editing and polishing the video, there was a lot of material repetition*"; this helped him to understand and remember the material very well. In the course evaluation survey, however, only 3 respondents said the video was valuable for their learning, while 6 respondents said that it did not support their learning.

One negative point of view that students expressed in the interviews was that video making was unnecessary extra work, and the material was learned through conducting the interviews and writing the text reports. *"I don't think it improved my learning in a specific way, it felt like an extra thing to do. I wanted to spend more time on the interview analysis for the written report rather than on the video making",* – explained S3. Many groups, in fact, made their videos and reports almost identical despite the instructors' idea of making them to complement each other.

Finally, when asked how their group video would compare to other group videos, only one student (S10) said in the interview: *"I didn't like our video"* and wished he saw other groups results before the submission: *"if I saw other videos, I would try to make mine better".* 4 other interview participants felt their video was about average in the class, and 7 respondents exhibited feelings of satisfaction and even pride for their creations (**T9**). S2 said: *"I thought the video that we made was super-good!"*; S12 said: *"We did a great job!"*; and S7 added: *"I think ours was much more entertaining. It was enjoyable and fun to watch our video".* Interestingly, even S9, who said the video part of work was pointless, commented: *"I think we did fairly well. We didn't do anything silly, but we were creative [TV anchor interviewing a reporter], and you could get the information we wanted to deliver straight away".* This confirms that a majority of the interview participants not only positively accepted the idea of video making for their assessment, but also enjoyed the video-making process and the end results of their work.

To answer the research question **RQ 2A**, I summarise the main findings below:

- Creating video artefacts was not something the students in this case study were accustomed to and knew how to do. Only a minority of the students had previous video making experience.
- Nevertheless, the majority of the students thought the video making task was not difficult, and the absence of previous experience did not put them off. Only a few of the interviewees complained about the time they had spent on video editing.
- Most of the student were happy with their final artefacts.
- Most of the students engaged in critical analysis of the videos produced by their peers, without realising that this was part of their learning.
- The majority of the students did not believe the skill of video making would become useful in their future career. Furthermore, many of them did not understand the how video making could help them to learn the course material.

b) RQ 2B

The **RQ 2B**, specifically the aspect of **acceptability and experiences of learning from video materials created by other students**, was covered by themes **T10** through **T16**, see Table 5:1 above. The aspect of learning from student-produced materials can be explored from two perspectives:

- learning from videos versus learning from texts (**T10**-**T12**);
- learning from peer-produced materials versus learning from instructor-produced materials (**T13**-**T16**).

The video versus text preference reflected the fact that different people prefer different learning media/styles. 5 out of 12 students said in the interviews that they preferred to learn from videos (**T10**): *"I think, I'm more visual. So, for me, it's always easier to watch a film than read a report",* said S12. On the other hand, 3 out of 12 respondents said the opposite: *"So, like you could just read report and then like skim through the video because it was faster to read a report than watch the video",* said S11. At the same time, 5 interview participants highlighted the fact that videos were good for getting an overview of the presented information quickly and easily while the reports were good to explore and understand the issue in details. S3 elaborated that:

> *"It was sort of a quantity versus quality thing. The reports were much better to read to completely understand the situation. While, watching a video was so quick and easy that you could watch several of them and realise 'oh, this is a problem in*

both this case and that case, and that case too, so it's probably important'. But the specifics of the problems and the way to solve them in various ways were more a report thing."

This suggests that at least these 5 students understood that a video and a written report were meant to supplement each other by delivering the materials in two different formats. Students who shared this opinion added that videos were very helpful when they gave something new, for example, showing the context or environment of the reported issue. However, not every student group was successful in understanding the point of creating two different formats of the report, so "*some videos weren't as helpful as others"* because they just directly repeated the text reports (S7).

Traditional education, especially in STEM subjects, usually helps students to learn how to read and write texts rather than to create meaningful multi-media messages. As S9 commented: *"We have written zillions of reports, so we know how to deliver a message through text".* This was, perhaps, one of the reasons why in some student groups the text part of the projects was better than the video part. When asked if it was easier or harder to learn from videos (**T11**), 5 interview respondents stated that a few videos were more difficult to understand than their corresponding text reports. S1 commented: *"[learning] was pretty hard from some videos because it felt like some groups hadn't grasped the purpose of the video, that the videos were actually supposed to teach something",* while 4 other interviewees did not see any issues with learning from the videos: S4, for instance, *"didn't feel a need to read the report or anything else"* after he watched the videos. Bearing in mind that some of the videos, in fact, were not made to a satisfactory level of content quality (those groups had to do an additional assignment to pass the coursework, but there was no time for them to redo the videos before they were shared with other students), this suggests that students like S4 were not critical enough when watching and learning from student-produced materials. Fortunately, at least 5 students who gave interviews saw the problem with the content quality in those videos. S2 for example, said that some videos did not deliver the necessary message/clear information. S7 added that: "*some videos were just, like the level was pretty basic what they were talking about, and at the same time, it was a very boring video."*

In general, the interview respondents indicated that the quality of the student videos was about "50/50", with some very good videos and quite bad ones too. Student responses in the course evaluation survey supported these results. The multiple-choice question about peer-produced videos received an equal number of responses (n=5) to the statements: *"taught me a lot about the course topic"* and *"did not teach me as much as I had expected about the course topic"*.

It is important to emphasise that videos were judged as poor not due to their technical qualities or videography (**T12**). When asked whether any flaws in the videos had negative impact on learning from them, S2 clarified:

> *"I think it's not the video quality, it's the message, and also we have come to a thing that, it doesn't have to be like a super 1080 pixel or anything, it's like a normal video quality would do for learning from it."*

3 students commented in the interviews that one of the videos *"was acceptable, but it wasn't that good"* (S1), and that its audio quality was poor due to wind interference, while all other videos *"were just fine"* (S9), and their *"quality was pretty OK, in fact. So, technically, I would say, I didn't need to watch the videos again. I didn't have to rerun them"* (S2). In total, 8 students in the interview said that all of the groups met at least the baseline on the technical level of video quality. This was also supported by the course evaluation where 4 respondents said the videos *"were an accessible course material"* versus only 2 responses saying the videos *"were hard to understand"*.

Overall, with an exception of S9, all interview participants in one way or another indicated that learning from the peer-produced videos was an interesting and enjoyable experience. In the course evaluation survey, 50% of respondents (7 out of 14) stated that the videos "*were a fun course material*" while only 21% (3 out of 14) disagreed: *"I did not enjoy this way of learning about the course topic"*. These results suggest that with an exception of a small number of cases, the student-produced videos were a useful and enjoyable teaching resource. The students who generally prefer learning from visual sources of information highly appreciated them.

The question of whether the students would prefer the videos in this course to be made by their instructors or other external experts (**T13**) was closely related to the general attitude towards peer-learning (**T15** and **T16**). Here the interview participants provided a few interesting insights. On the one hand, all of the interviewees presumed that the instructor-made videos would be of higher quality: they would be more instructional and *"more to the point"* (S11) which is *"mainly because instructors tend to care more about what they produce"* (S3). Yet, interestingly, only 4 out of 12 students said they would actually prefer instructor-produced materials to peer-produced materials. Furthermore, 7 interview respondents said that it would make no sense in this particular teaching and learning model. For example, S7 suggested that:

"*If the instructor made the videos, they would not be part of the dynamic of peer-learning, the discussions around the videos would be very different… I mean, the learning would be more like 'absorbing information' rather than 'critically, actively developing an understanding'.*"

Moreover, as noted by S10, even if the instructor-produced videos are perfect in terms of quality and content, *"it is better to watch the student-made videos, as it's more interesting, more fun. Because we are learning together, we are doing some things together, so I'm looking at their efforts, they are looking at mine and it helps me to learn".* These observations suggest that the students in fact appreciated the peer-learning concept of the Self-Flipped Classroom approach.

The students also explicitly expressed their preference to their classmates as the video authors, stating that if the videos were made by other, non-familiar, students, the motivation and enjoyment to watch the videos would have been lower. S8 elaborated:

"I enjoyed watching more the people I knew in the videos because I thought that was funny. It's not going to be funny anymore when I look at people I don't know. Maybe if they put some humour in it… but not just because they show their faces, like you started smiling when you saw one guy's face! So, that will give a different aura on the whole thing because then you aren't as focussed since you don't really care if you see everybody's videos. But if you know the people, you will actually want to watch every single one of them because you want to look at their faces and their work and everything."

In addition, S8 and S11 expressed a similar opinion that instructor-produced videos would be significantly less interesting to learn from: firstly, because they would likely be more serious, and secondly, because that would be just one person presenting the information, and thus the facts might blend together. In particular, S8 said:

"If the teacher had made all the interviews herself and told about everything - I think that would have been actually a real headache to look at because they would be the same pattern almost every time, because it's the same person. So, no, I do prefer listening to a lot of different people compared to just one, for this."

S12 added to this: "*I think what made a difference was that it was funny to see your classmates doing something different and portraying it in a very specific way".* According to these respondents, every group of students gave a different perspective to the topic they reported about, and watching 12 videos presenting a lot of different perspectives was perceived to have worked much better compared to watching 12 very similar videos.

The students have also highly appreciated the peer-learning approach (**T15**) based on constructive controversy and affinity diagram techniques. 8 interview respondents provided comments similar to those by S4 who said:

> "*I liked the fact that each group covered a piece of a matrix. It was interesting to see how our work fits into the matrix, also was interesting to see what was different and what was similar in different organisational contexts."*

Only S5 noted a downside of such a learning approach, saying:

> *"One of the problems with this method of learning, is that the students are collecting and presenting the information. If they miss something then the rest of the class will miss it as well. But it's a good way to collect a lot of information."*

9 out of 12 interview respondents said that it was great for them to learn from materials produced by their classmates (**T16**). S4, for instance, stated:

> *"I appreciate the concept of making your own video and then watching everyone else. I guess, you could relate more on what they were trying to do, when they are your fellow student, because you know the authors, and you did the same work. I was always interested to see what others found as most interesting to present in their video, somehow comparing their content to our video"*.

Finally, one of the most interesting aspects of learning from peer-produced materials was the trust that the learners had for the information delivered in such materials (**T14**). In contrast to relevant literature, e.g. (Engin, 2014), and to the instructors' intuition prior to the course, the large majority of students, 9 out 12, said in the interview that they had no doubts at all when learning from the peer-made reports. For instance, S11 said: *"No, not really. I trusted my other students that they delivered information from the interview, what their interviewee has said. I trusted that it would be correct"*. The students knew, that all the materials were checked by the instructors before being shared with the class, and so S8 said that if the instructor "*looked at them as well, I think, that hopefully it was pretty correct"*. Three other interviewees made comments about opinions and interpretations of the information. In particular, S3 reported:

“In the absolute majority of cases, I trusted my classmates. I don't think they would lie, that’s never. But in some of the videos there were some things that are more prone to interpretation, I felt such things might have been misinterpreted.”

S6 added to this:

“There wasn't enough time [in the video] to express everything because you had to summarise, you had to present things shorter. I think some people might have misunderstood some parts. I think, that the written reports were more comprehensive, they had more space to explain.”

S7 made an interesting remark when comparing student-made videos to videos made by the instructor:

“Of course, looking through those [instructor-made] videos people wouldn’t have any doubts about ‘this is my definition’, people would be like ‘OK, that’s the definition, I’m incorrect’. There would be more of that kind of thing, but with peer-to-peer it kind of opens up more of a discussion. Because then you are kind of like ‘OK, wait, so this is my definition, this is your definition, why is this different?’”.

This suggests that the students had no or little doubts when learning factual information from peer-produced materials and did not question why those materials were not made by the instructor. It is worth noting, however, that this could have been caused by the nature of the materials in this particular case, that is, video reports based on expert interviews. Peer-produced reports summarised and presented the experts’ knowledge, which can be perceived as less prone to misconceptions and errors compared to creating new materials, finding new solutions, or drawing independent conclusions. The students did realise that there was a possibility for information misinterpretation, yet this did not have a negative effect on learning from these materials. In fact, watching peer-made videos stimulated more thinking and more reflection in the students than it would have been if all of the resources were made by instructors. Finally, since all of the student-produced materials were checked/endorsed by the instructors before being used for others’ learning, students were reassured that the materials were free from errors and misconceptions.

To answer **RQ 2B**, the students **accepted** the video materials created by their peers as trustworthy and suitable for learning. Their **experience** of learning from these materials was generally positive, although it is worth noting that traditional focus on producing text reports meant that students were not experienced in producing videos, and some students questioned the need for learning from videos in addition to learning from more familiar text reports.

5.4.2 RQ 2 through Analysis of Student-Produced Videos

This section continues to address the **RQ 2** and presents a further analysis of the student interviews and their final videos produced in Case Study B. I will discuss the following themes here: (i) the students' approach to choosing a particular style and format for their videos *as creators*; and (ii) the students' perception of different video styles and formats *as learners*.

This additional layer of analysis of *students as prosumers* helps us to further explore the students' attitude to the SFC elements of production and consumption of learning artefacts. I strongly believe that the final student artefacts objectively demonstrate students' attitude towards this part of coursework and shed some light on students' real experiences. By analysing student artefacts in addition to their interviews, we gain a deeper understanding of student behaviour and can draw useful implications for a general SFC course structure to help guide instructors who implement SFC in future.

As seen from the student interviews, it was the students' first ever experience of video-making as part of a course assessment. More generally, they were not used to creating videos for the purpose of teaching or demonstrating something. Consequently, the students did not have a clear idea or a set of "standard" principles in their heads for how their video report should look like. Moreover, the course instructors made the assignment brief rather open: the brief specified the video length limit (3-5 minutes) and a requirement to deliver results of a field expert interview (that is, the video had to be instructional for other students), but there was no particular guidance regarding the format or style of the video. Thus, the students had the freedom to choose how to make their videos and the groups worked independently without any centralised facility for sharing or discussing pre-production materials (unlike the Ubicomp case study from Chapter 4, where video templates and pre-production materials were stored and shared centrally via Bootlegger). This resulted in a great variety of videos in terms of format, style, and technical characteristics, as well as the quality of content.

Table 5:2 lists the main technical and stylistic characteristics of the student produced videos. I do not include any evaluation of the videos in terms of the quality of presented information or fulfilment of the course assignment, because this was part of the assessment criteria used in the

Table 5:2. Analysis of student-produced videos.

	Group	Length in minutes	Format	Style	Comments
1.	Group A1	3:53	Monologue	Serious; re-telling the interview	Outdoors, good technical quality
2.	Group A2	5:25	Dialog	Serious; edited footage with questions and answers from the actual interview	Indoors, good technical quality
3.	Group A3	4:59	Monologue	Serious; written questions in English accompanied by cut-outs from the actual interview in Swedish	Indoors, good technical quality
4.	Group A4	4:39	3-person conversation	Serious; re-telling the real interview	Indoors, good technical quality
5.	Group H1	4:10	TV news with a 2-person interview	Playful; re-enactment of the real interview with humorous elements	Indoors, good technical quality, jokes
6.	Group H2	3:46	Slide show / Narrated video	Serious; written questions with written quotes in English and audio cut-outs from the actual interview in Swedish	Good technical quality
7.	Group H3	4:20	Monologue	Serious; written questions in English accompanied by cut-outs from the actual interview in Swedish	Indoors, good technical quality; video available only for the first minute, the rest is audio only with written questions on the screen
8.	Group H4	5:00	Dialog	Serious; re-telling the real interview	Indoors, good quality
9.	Group P1	4:01	Monologue	Serious; re-telling the real interview	Outdoors, good technical quality with only slight wind and birds as background noise
10.	Group P2	3:49	Dialogue	Serious; interview re-enactment where the answerer, who pretends to be the real interviewee, is on the video and the interviewer is behind the camera	Outdoors, mediocre quality of picture and poor sound
11.	Group P3	3:38	TV news with a 2-person interview	Playful; re-enactment of the real interview with humorous elements	Indoors, good technical quality, good acting, many jokes.
12.	Group P4	4:59	Talk show with a 2-person interview	Playful; re-enactment of the real interview with humorous elements	Indoors, good technical quality, good acting, jokes

course and the ethical guidelines of Uppsala University do not allow for any assessment-related information to be disclosed. In the group identifiers, “A” stands for administration, “H” – for health sector, and “P” – for private companies. In the Comments column, “good technical quality” means that: (i) the audio is clear, has no extraneous/background noises and allows for everything what is said to be clearly heard; and (ii) the video is clear, in focus, not shaky, and doesn’t otherwise disturb the viewing of the presented information.

In the next section I discuss different approaches that the students took for their video creation with regards to style and format.

a) Style and format of the video

Comical vs boring

There were two videos which were mentioned as examples in almost every student interview. The first one was a particularly comical video, where the authors tried to convey their material in the form of a playful and humorous TV show (see Figure 5:4 for a few screenshots from this video; note: the peculiar camera framing in the middle shot is intended as a joke). The second one was the opposite: it was an example of a boring monologue, occasionally interrupted with questions, shot somewhere in the woods where wind interfered with the audio quality (see Figure 5:3). A further discussion of the students’ attitude towards these types of videos is provided below.

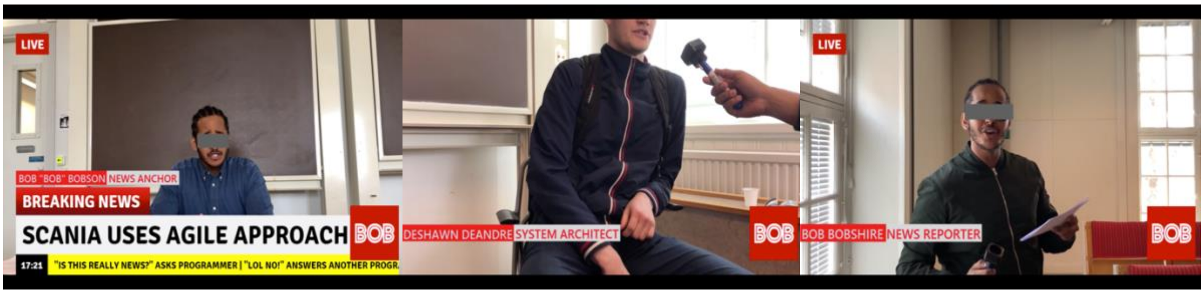

Figure 5:4. Screenshots from a video where students re-enact an interview in the format of a comical TV news programme.

Figure 5:3. Screenshots from a video where students re-enacted an interview in the format of a simple monologue.

The authors of the first (comical) video, S7 and his group were certain that in order to create a good video they had to make it interesting in some way. S7 explained his position: *"Keeping the interest, I think, that would be the thing with the video. Since it's another format of learning then you have to keep them interested, I guess".* This group chose to use humour and included playful acting, jokes and 'Easter eggs' (hidden messages) into their video. A majority of the interview respondents found the resulting video to be the most interesting. S8: *"I liked that video with 2 persons interview play and with humour. The Easter eggs helped to remember the factual info, as you needed to re-watch the video to look for them, and it was enjoyable too. So, I really remember what they were talking about".* The interviewee S1, who liked the video assignment because it allowed him to make interesting things, elaborated further: *"I mean, like if we're allowed to do videos, let's try to use the entire format and make it interesting! I mean, listening to a long monologue wasn't interesting at all".* It is not a surprise that the majority of the student interviewees agreed that the interesting videos were more enjoyable to watch and to learn from.

This can be compared, for example, with S6, who created the video in just 30 minutes and later said that it was too simple. He also explained that he thought that the point of the video was to simply compress the entire field expert interview into 5 minutes and retell it. As a result, his group presented the interview as a monologue narration. Their video received a lot of criticism from their peers as being boring and hard to learn from. Not surprisingly, as a learner, S7 (the author of the most popular video) found that most of the videos produced by other groups were very boring. S1 agreed with this, saying that, for instance, the "monologue in the woods" video was not motivating to watch and to learn from: *"it delivered the information, but I wasn't as interested watching it as, for example, looking at someone who did a TV show".*

Interestingly, 3 students commented in the interview that the video with Easter eggs was also not easy to learn from, as it was a bit too funny, so it distracted from the content. S9 said: *"Funny is not always good for learning process"*. Overall, only the respondents S3, S5 and S9 said that being funny was not always good; others said that they watched and re-watched funny videos several times and learnt the facts better, since it was interesting to re-watch it (to find all of the Easter Eggs, for instance).

These observations relate to the **RQ 2** and suggest that the students had a perception of a fine line balance for the teaching materials to be interesting and engaging as opposed to boring and distracting. In the ESF classroom scenario, students have the freedom to choose the style and format of the materials they create, consequently they receive a wide spectrum of materials to learn from. This variety of styles coupled with the familiarity of creators and consumers give the students the opportunity to be more opinionated. In contrast, the interviewees noted that instructor-created materials would be more homogeneous and also command more authority, since they would be less prone to be out of that fine balance.

Creative vs Customary

Some of the students chose to make a simple cut and edit of the interviewee's responses, as well as a Power Point slide presentation with a voiceover narrative or a headshot frame of one person telling a story in a monologue. Student groups that included somebody with a good camera, and who knew how to make videos and/or did not mind to be filmed, exhibited more creativity by creating less traditional instructional materials, such as a TV show, news reports, and playful re-enactment of the interviews. As noted by S3, this was likely a consequence of not having any standard templates to follow:

> *"If there were an example of video made by instructor, it would limit the variations and the creativity, because the students (who less creative anyways) would just think 'this is how it should be done because it's your instructor' and repeat the same format."*

We can therefore conclude that providing students with more detailed instructions, examples or templates for their artefact creation is a balancing act and the instructor should understand both benefits and drawbacks. Specifically, the benefits include better quality of the produced artefact and greater acceptance of the pedagogical approach by students as creators, while the (hypothesised) drawbacks are the reduced motivation and engagement of students as learners.

b) Authoring versus using peer-produced materials

The students generally appreciated the peer-learning element of the teaching format and the wide coverage of the information which was possible because several different groups investigated different topics. A majority of interview respondents (8 out of 14) thought that they learned more from making their own videos (as well as the text reports); for example, S11 said: *"this new model of teaching added learning value but mainly from the video that we made, the other videos I don't really remember as much."*

The students also often commented on how watching videos made by their peers stimulated their thinking, e.g. to compare the content (facts and approaches), the level of understanding when the focus of the projects was similar, as well as to question the opinions and definitions presented/articulated by other students.

Based on these observations we can conclude that the students saw more value in the first phase of the SFC approach as they thought that creation of the artefacts gave them new opportunities to learn the course material. The second phase of the approach (the consumption of the peer-created artefacts) was less appreciated by the students: they agreed that they could learn the course material from student-produced artefacts, but did not recognise that learning from these artefacts led to additional thinking processes (in addition to learning the facts), specifically while watching the peer-produced videos. When prompted during the interviews, however, they did admit that those thinking/learning processes took place, and acknowledged the interest of watching, and sometimes re-watching, videos produced by their classmates due to personal connections with them. These observations feed back to the **RQ 2** highlighting how the SFC approach impacts student learning during both phases of the approach.

c) Reflection and feedback

Some students who failed the video-creation part of the course, were asked to write a "What I'd do better" document, reflecting on their video-making experience. One of the students (S5) said: "*I think it would have been better to have that feedback before and maybe redo some of the videos*". Other students also suggested to provide more feedback on the video-making part of the assessment before the submission of the final videos.

Furthermore, S10 would have appreciated to see good video examples beforehand: *"If I see a video, I would try to make mine better"*. However, as discussed earlier, while this can indeed raise the overall quality level of videos, there is a risk of inadvertently suppressing the students' creativity and thus reducing the variety of student-made videos, making the course and studied material less memorable.

These observations suggest the following implications for a general SFC course structure. Firstly, predictably, the students will benefit from formative feedback (Race, 2009). This may be even more useful in a context of a non-traditional form of learning where students are less likely to be sure of what is expected from them in terms of coursework. This is related to the student experience part of **RQ 2**, in terms of the expectation for more coursework guidance and support. Secondly, as also expected, the formative feedback needs to be non-directive and non-prescriptive (Gürsoy, 2013) to provide space for creativity and affordance for different learning styles, which is what SFC aims to stimulate.

5.4.3 RQ 3

To answer the **RQ 3** on the instructors' attitudes to and experiences of SFC, I decompose the **attitude aspect** into the initial motivation and post-evaluation or reflection. The **experience aspect** can then be covered by a description of the instructors' teaching activities during the course, as well as the challenges and opportunities they encountered. Thematic analysis of the instructor interviews revealed the following themes, which are presented below:

- ***Motivation and reflection;***
- ***Teaching experiences:***
    - ***Quality of student learning;***
    - ***Assessment of non-traditional coursework;***
    - ***Ethics;***
    - ***Thechnical issues.***

I start by discussing the ***motivation and reflection*** of the instructors who decided to introduce the Self-Flipped Classroom approach into their teaching. It is worth noting here, that the instructing team became familiar with SFC after attending my ITiCSE'17 conference talk, where I shared the experience of student content creation from Case Study A (reported in Chapters 4 and 6).

Both the course leader (CL) and the teaching assistant (TA) of the "Complex IT systems in large organisations" were intrinsically motivated to try the Self-Flipped Classroom approach in their practice. The course leader tends to organise all her courses around student-centred active learning and when she was asked to design a new module for a Master-level programme she proposed to incorporate the reuse of student-produced artefacts into the teaching. She said: *"We had a workshop with like post-it notes and a lot of discussions of ideas about what would be fun to do in the new course"*. The workshop participants supported the SFC approach and *"so the whole course then was built around this idea"*. The teaching assistant also saw a great value of the approach for their students:

> *"I personally think that it's good that they actually learn to do things like that [creation of instructional materials]. That they get out of their comfort zone and that they learn to reflect on what they see and do in that way. So, I think it's definitely valuable! But I can understand that students may not have that perspective."*

The attitude of the instructors towards the Self-Flipped teaching and learning method stayed positive from the very beginning to the end of the course. Despite the challenges in running such an innovative course, the team continued using the same approach in the next iteration of the course. Both instructors were confident that the students learn better in the SFC model, and that the "love it or hate it" attitude of the students could be avoided by better preparing them to the unusual structure of the course, and explaining its rationale and benefits.

To address **RQ 3A**, which relates to the ***experiences*** of the instructors, we review the opportunities and challenges that SFC presented to the instructors. A major component of teaching experience is ensuring the best possible ***quality of student learning***. In Case Study B, this was both the main opportunity and the main challenge for the instrustors.

The main opportunity that the SFC gave to the instructors was creating an atmosphere of active learning through the discovery and creation of knowledge. When asked to reflect on differences between traditional lecture-based teaching and the SFC approach, the CL said that SFC was *"much more motivating. I'm also very convinced they [students] learn more".* Furthermore, an SFC-based course like this, where students are learning through collecting and processing data from the real world, for example, interviewing field experts and delivering the collected information to the rest of the cohort, is also more enjoyable and fulfilling for the instructors themselves. The CL explained:

> *"I would say it's much more fun. And you learn more yourself too. Because you learn from the students, you are in the group, learning from whatever they heard. It's not that you know what they said in the interviews, because you can't know. I mean it's generated from real people, so it's much more interesting."*

Both the CL and the TA expressed their belief in the great potential of this approach, taking into account how much effort and resources is typically required for instructors to collect up-to-date expert knowledge and incorporate it into teaching materials.

The biggest challenge from the point of view of the instructors was that they had very little control over the quality of student-produced teaching materials, which directly impacted the quality of learning from them. The CL elaborated:

> *"We had a situation where we did not pass a few students [for the group project report]. And in the end, we decided not to let them redo the film because there was no time really. So, we made them reflect on what they should have done better and hand that in, and then I graded and passed it. Because otherwise there would be a*

hole in the matrix of what they did. I mean, no student did the same film as another student so all the films were needed to get the full picture. Which was good because that's very motivating but when they failed, we had a problem."

Both of the instructions were worried that a portion of the teaching materials that had to be released to the students was not of good quality. This subsequently negatively affected learning experiences of students who saw that the material was not perfect, resulting in a considerable amount of negative feedback.

In addition, as has already been mentioned in the student attitude part (Section 5.4.1) of this chapter, with the course being too different from what the students were used to, some of them were sceptical about the new way of learning from the very beginning of the semester. Referring to the polarised course evaluation results, the TA commented:

> *"I don't think that the students necessarily saw it [the value of SFC] this way because we put some more constraints and some more work on them and I think that they might see that work as irrelevant to the topic, right? Like 'we didn't take that course to learn how to do videos' for example."*

The "hate it" part of the cohort required an extra effort of selling the idea of innovative learning. So, it was a challenge for the instructors to ensure that these students were motivated to produce good quality materials for the sake of their learning, as well as the learning of others.

The instructors reflected that they needed to stimulate student thinking about what and why they were doing as part of the course assignment, which was especially important when the students were asked to do non-conventional coursework, such as interviews and videos. The instructors agreed that they needed to be more prescriptive and give more directions to stimulate the intended learning processes, as explained by the TA:

> *"[To improve next time] to give clearer instructions. I think also, really ask them to talk about their experience and not just using bits and putting them together so that you have the length of the video required right. So then definitely require that background work, so that they actually have to process something, when doing the video."*

One could also draw similar conclusions from Case Study A, where some students took a complete sequence of clips created by other students and submitted it as their work. Such pathological "reuse everything" approaches needed be explicitly discouraged. This leads us to another important consideration of the student-content creation – the assessment of the final artefacts. The theme of ***assessment of non-traditional coursework*** was very important both to the instrustors (who needed to create assessment criteria and "sell" them to the students) and to the students (who needed to understand why they were creating a particular type of coursework and how exactly it reflected their subject learning).

The CL commented: *"We were so happy we had 'pass and fail'"* for the video and report parts of the coursework. She explained that, when running the course for the first time, it was difficult for them to foresee what kind of materials the student would come up with, and it was even more difficult to decide in advance how to grade them. Therefore, they decided to use (i) the 'pass and fail' grading, with the criteria for 'pass' being rather low for this part of the work, and (ii) a more challenging final exam where the students had a chance to further demonstrate their knowledge and achieve an excellent course mark.

Another challenge that put constraints on how SFC could be implemented was that of ***ethics***. When it concerns students, universities have very strict regulations on what could be released. For example, the instructors of "IT systems in large organisations" could not reveal which videos were below the necessary level of quality to the rest of the class. CL explained: *"We could not tell the other students about the videos that did not pass, because we can't disclose that kind of information about students"*. Furthermore, if they decided to reuse the videos from one cohort to another, the videos would need to be "approved" and consent obtained from the authors, making it practically difficult to accumulate a library of high-quality student materials.

Ethics aside, there is also a clear trade-off challenge in reusing videos from previous years. Such reuse could improve the overall quality of the teaching materials and give more control to the instructor, but at the cost of losing the personal connection between the students who learn from the videos and the students who create the videos. If the students do not know the creator (another student) then they might start asking why the instructors did not make the videos themselves.

One more challenge that arose from the introduction of video making as an assessed coursework, was the ***technical issues*** with the set up for handling such student artefacts. The CL recalled:

> *"We thought, we had a good technical solution. We have a system called 'Filr' here, which is a storage system for files for university employees. And you can just*

open it to other people and they can just use it as a folder. Like a Dropbox thingy. But, it didn't work… because the films were so big."

They could not use YouTube either, because *"We thought that [interviewed] people would react if we asked them to be filmed and then we put them on YouTube",* even if it was going to be a private channel. We can therefore conclude that, in such cases (that is, when the SFC implies the creation of video artefacts which tend to have large sizes) there is a need for a dedicated platform which would allow for convenient, scalable and ethical way of handling (specifically: submitting, assessing, and reusing) students videos.

Summarising the findings presented above, I can now answer the **RQ 3** as follows:

1) The instructors' **attitude** towards the SFC approach was positive and optimistic initially and stayed this way throughout and beyond the course despite the encountered challenges. The instructors believed that with the right amount of effort from them, the students would benefit more from such a pedagogical approach as SFC compared to the old traditional lecture style teaching. Moreover, it was more interesting and fulfilling to teach in that way.
2) In terms of their **experience**, despite their meticulous preparation and development of this new course, the instructors did not see all of their expectations to be fulfilled. The instructors also experienced a number of unexpected challenges. (That there would be *some* challenges, of course, was expected: innovation is hard, and running a new course based on an innovative pedagogy is never straightforward.)

As for the research question **RQ 3A**, the **challenges** encountered by the instructors included: (i) having little control over the quality of the teaching materials that the students produced for their peers; (ii) a large amount of effort needed to 'sell the idea of innovative learning' to the students who preferred to learn traditionally (that is, more passively); (iii) designing assessment criteria for multimedia artefacts that would stimulate deeper learning; (iv) ethical issues related to privacy, anonymity and consent to reuse the student-produced materials; (v) the trade-off between improving the quality of the student-produced materials by reusing the best materials from previous cohorts and losing the interpersonal connection among the students prosumers; and, finally, (vi) the technical issues of sharing the produced video artefacts, drawing attention to the need for a dedicated platform to help instructors handle student-produced video materials.

On the positive side of **RQ 3A**, the instructors highlighted the following **opportunities** that the SFC approach brought them: (i) create an active learning environment for both the students and for the instructors themselves, because the initial data was "generated from real people" via student-conducted interviews; (ii) increase the engagement of students with the teaching materials thanks to them being produced by their peers; (iii) incorporate up-to-date expert knowledge into the course without the need to regularly conduct and transcribe the interviews by themselves; (iv) develop critical thinking in students by exposing them to a content matrix with entries coming from a diverse set of authors and having different technical quality; (v) get the students out of their comfort zone and expand their view of how Computer Science education should look like; and, last but not least, (vi) enjoy a new way of teaching.

5.4.4 Summary of the Results

In this section I summarise the results presented above by answering the **RQ 2** and **RQ 3** in a more concise form:

RQ 2: What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?

RQ 3: What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?

a) Students

As often happens with new ideas, the SFC teaching approach received a mixed response from the students. Due to the lack of previous experience with such forms of teaching, the students were generally not ready for active learning methods involving video content creation, which led to the "love it or hate it" split within the observed cohort. Students who appreciated the SFC, enjoyed the course and learned better through the creation of good quality materials, which further engaged and inspired their peers. On the other hand, the students who did not understand the purpose of the SFC or did not like its form, created poor quality materials, which negatively affected the learning of their peers, and also attracted criticism of the whole cohort, i.e. from both sides of the split.

By combining video creation with much more traditional text reports, the instructing team successfully accommodated for different learning styles and preferences. Moreover, thanks to the nature of the Enclosed SFC, the whole student cohort benefited from personal connection between students-as-creators and students-as-learners, which led to their increased motivation and engagement, as well as critical evaluation of the created materials.

b) Instructors

While the instructing team was convinced of the benefits of the SFC approach and planned to continue using it in future iterations of the course, they were faced with a number of challenges. Their overall impression after running the first iteration of the course was that their aspirations and goals for high quality active learning were not fully fulfilled, and their efforts to prepare and scaffold the students did no fully pay off. They found it difficult to provide the right level of scaffolding for all of the students and to ensure the high quality of student-produced materials without being too prescriptive. This led to the abovementioned "love it or hate it" split within the cohort. The resulting diversity in the quality and style of the created video materials made them difficult to assess.

There were also some challenges that can be addressed by technological and administrative innovations, specifically: (i) technical issues of producing, sharing, storing and archiving student created video content, and (ii) ethical considerations and processes that need to be put in place to manage student privacy, especially when students appear in videos, intellectual property and the reuse of the created artefacts, as well as non-disclosure of assessment results.

Despite the challenges, the instructors identified a number of opportunities that the SFC approach brings, such as the ability to incorporate up-to-date knowledge of real-world experts into the course, increase the engagement of students with the teaching materials due to their personal connection with the creators of the materials, as well as developing the critical skills of students and generally expanding their view of how Computer Science can be taught.

5.4.5 Discussion

According to the interview participants, students did not anticipate that a required course on a CS/IT programme of study would involve anything like interviewing or video making: the whole approach to the student-centred learning was unfamiliar to them; students also mentioned that they expected the course to be more technical and more difficult. These findings are consistent with literature on the professional identity of CS and IT engineering students (Peters, 2018) in that students believe that they only need to know how to code well for their successful career.

Some of the students said that they saw value in the interview part of the assignment as it helped them to learn how real-life IT specialists work, but they believed the video part was a waste of time: *"We don't need to know how to make films for our future career"*. Nevertheless, students were motivated to watch the films created by their classmates. They wanted to see familiar faces and check what their peers had come up with. This would be different if the videos were made by someone else. Contrary to findings in Engin's study (2014), our participants said they would *not* prefer if the videos were made by the course instructor or another expert.

Students often enjoy and benefit from a particular pedagogy if it aligns with their preferred style of learning. There was a clearly identifiable division of our interview participants into two groups: (i) those who prefer to learn from reading – they did not like learning from videos and said that it was quicker and more efficient to read the reports (as they could easily skim text and get back to a needed part); and (ii) those who prefer to learn from videos – these students appreciated the videos much more than the reports, saying that it was quicker and more enjoyable for them to watch the videos. Again, this is consistent with literature on learning preferences (Felder & Silverman, 1988): the students who prefer learning by watching and listening would be more inclined to support learning as prosumers of audio-video materials; and, conversely, there will always be students who enjoy reading and writing more.

Despite initially not seeing value in video-creation, the student interviewees all agreed on the fact that video making and watching was a fun and enjoyable experience. Students also admitted that the video creation made them really understand and remember what they learned by interviewing experts, which is consistent with the findings of Hoban et al. (2010). However, the course instructors said that some of the student-produced materials were of poor quality. Furthermore, not all students in the class understood the purpose of the video making task, so they did not engage with the task properly and did a bare minimum to fulfil the assignment. Notable examples of such videos included showing students who simply read extracts from the interview. This is in line with the findings from a study by Maguire, Draper, & English (2018) that today's students are not as "digital natives" as we think of them and require more scaffolding with video making than we anticipate. These students not only failed to achieve the expected learning outcomes but as the result their group videos were of borderline quality. Unfortunately, since each group has been assigned to cover a specific phase of IT system development in a specific context, the instructors had to include all of the videos and reports into class discussion and exam preparations. The course timetable was tight and there was no time to redo the videos. This echoes the instructors' challenge of not being in full control when teaching using student-produced materials, as outlined in Miño-Puigcercós, Domingo-Coscollola, & Sancho-Gil (2019).

Additionally, as reported by students in the interview, not every one of the students who used the videos and reports as learning materials saw major issues with them. Furthermore, students said that it was not difficult or time consuming to make videos, some even felt it was too easy, which is linked to the lack of understanding of what was required from them.

Again, in contradiction to Engin's study (2014), students in this case study did not see any issues in trusting the videos and reports created by other students, despite the quality concerns noted by the instructors. Only when asked in the interview to reflect on the quality of the peer-produces videos, the students commented on some of the quality aspects but still did not doubt the content of the videos, even after acknowledging that there might be a place for misinterpretation of the presented information. This can be explained by the following factors. Firstly, the videos and the reports were assessed by the instructors prior to sharing them with the rest of the class. The results of the assessment were known only to the student-authors, and the rest of the class did not know how other materials had been marked. Hence the student-learners may have assumed that each video and written report had passed the quality check. Secondly, as the materials were summarising results of the interviews with real-life experts, students might have assumed that there was not much space for incorrect or misleading information created by the student-authors. Finally, Computer Science student culture and the tradition of their learning practices could have another level of impact here: the students in studied case were generally not accustomed to the creation of non-technical pieces of coursework and not trained to be creative in this regard. Therewith, the students were not accustomed to the learning from non-traditional teaching resourses, so they did not think it was necessary or useful to critically evaluate the content of these teaching materials.

The issue of trust is not one dimensional. On the one hand, the learners have to accept the delivered information as correct, as otherwise they would not be motivated to watch or read the peer-produced materials. On the other hand, "questioning" the delivered facts is a healthy habit for learners: it stimulates their critical thinking skills and their reflective learning. This is especially true when the learners are also the producers of the same or similar materials – they evaluate and consume the information and the method of delivery differently. The respondents of the study mentioned how they could relate to the authors when they knew them personally, also how they could relate to the factual information when they themselves were doing a similar task. Therefore, the Self-Flipped Classroom can be considered a promising approach for stimulating the necessary skills of critical thinking and reflection in student prosumers.

5.5 Chapter Summary

The main outcomes from this case study are as follows. Not all CS students from our cohort fully appreciated the value of "non-traditional" learning methods in their studies, most probably because it was introduced in a later stage of their study programme, and did not fit into their mind set. Nevertheless, the students found it entertaining to watch peer-produced videos as they liked to see what their peers were doing, compare their own videos to those made by others, and (unofficially) compete. There was also an indication that watching peer-produced videos stimulated additional thinking and learning processes.

Instructors who intend to try similar pedagogies have to think carefully on how to convey the value of being more than just a coder and how the proposed innovative teaching could help CS students to succeed in future. Findings of this study are in line with previous literature, e.g. (McGee et al., 2016; Peters, 2018), confirming that Computing Science students tend to have a limited view on what it takes to be a successful CS/IT professional and most of the time they find it difficult to come out of their comfort zone.

In peer-assisted and collaborative learning settings, more attention should perhaps be paid to the development of student critical capacity to evaluate the quality of the materials produced by themselves and by their peers. Spending a certain amount of time to ensure the clarity of the assigned tasks (e.g. what videos are for and how to create them) as well as transparency of the marking criteria to all students in the class may help. Another implication that these results suggest is that it is always a good practice to design course assessments so that they involve a range of learning styles and outcomes to cater for various learning style preferences and student abilities. As can be seen from the presented interview results, some students learned the course material from making and reading text reports, even though they did not appreciate the video component of the coursework (and vice versa).

Finally, it is worth emphasising that students tend to have more positive attitude towards the Self-Flipped teaching and learning when they fully understand the purpose of each part of the innovative pedagogy. In this study, the students who did not grasp the purpose of the video-making part of the learning activity and the course assessment had much better attitude towards what was customary for them already, e.g. text reports; they put less value on the peer-produced videos as a complementary teaching resource.

Chapter 6. Development of Transferable Skills in SFC

In addition to defining, grounding and evaluating the Self-Flipped Classroom approach as a new pedagogical model, this research was also concerned with a broader investigation into the ways of teaching a range of *transferrable skills* (also often referred to as *21st century skills*) through the learning by making approach. This chapter presents relevant data that was collected during Case Study A, as well as its analysis whose purpose was to record the development of transferable skills, such as media literacy and collaborative content creation, as part of learning in SFC. Consequently, this chapter answers the research question **RQ 4**:

RQ 4: What transferable skills and literacies does the Self-Flipped Classroom pedagogical approach help to develop?

Rather than aiming at answering the question comprehensively, which is hardly possible within a PhD project, I present two concrete and self-contained studies, both of which have been independently peer-reviewed and published (Vasilchenko et al., 2017) and (Vasilchenko et al., 2018). The first one focuses on *media literacy* and is presented in Section 6.1. Motivated by the observed collaboration and attribution patterns, the second study investigated student *collaborative content creation and attribution* and is presented in Section 6.2.

In this chapter I use only the data collected during Case Study A, because it relied on specific technology tools to support collaborative creation of learning artefacts, specifically, Bootlegger for video tutorials, and a discussion forum for blog posts. Thanks to close collaboration with the teaching team, I had access to rich quantitative anonymised data from these tools, which helped me to perform quantitative analysis in addition to qualitative one, thereby discovering unexpected and non-obvious patterns of student content creation, reuse and attribution.

Case Study B did not involve the use of any collaborative technology tools and the process of artefact creation was less collaborative in general (the collaboration happened only locally within small groups). It is worth noting however, that the data obtained from student interviews conducted as part of Case Study B does touch upon the topics relevant to this chapter, such as content creation, communication and collaboration. I will revisit this data in Chapter 7, in the context of a general discussion of computer supported collaborative learning and work, thereby extending the scope beyond just HCI or CS education.

6.1 Media Literacy

Understanding, promoting, and teaching media literacy is an important societal challenge. STEM educators are increasingly looking to incorporate 21st century skills, such as media literacy, into core subject education. This section presents a study on how students of an undergraduate HCI course can learn media literacy as a by-product of collaborative video tutorial production. The study is based on the analysis of the data collected during the Ubicomp course in 2015-2016, where each of the 34 third-year Computer Science undergraduates were asked to produce three video tutorials on Raspberry Pi programming, using a collaborative video production tool for mobile phones called Bootlegger. The data was collected as part of Case Study A, introduced in detail in Chapter 4. While I was the lead researcher on this study, a lot of credit goes to my collaborators and co-authors, David Green, Haneen Qarabash, Anne Preston, Tom Bartindale, and Madeline Balaam, on the corresponding paper *"Media Literacy as a By-Product of Collaborative Video Production by CS Students"* (Vasilchenko et al., 2017). I will therefore use the pronoun "we" throughout the rest of this section.

The section provides results of both quantitative and qualitative analysis of the production process and resulting video tutorials, and concludes that the student cohort demonstrated a clear development of media literacy skills. In addition to strengthening the case for SFC as a pedagogy that can help CS students acquire critical 21st century skills, such as media literacy, this section adds to the understanding of how the use of mobile collaborative video production technology by non-professionals can help them learn to create meaningful media messages with little scaffolding. Furthermore, by studying student behaviour in relation to the existing media literacy models, I propose to update the accepted model of media message creation by introducing a non-linear and recurrent process that involves the commonly recognised Access, Analyse and Create components.

6.1.1 Motivation

Computer Science educators, and HCI educators in particular, are increasingly concerned about teaching "soft skills" to their students. Today, a successful graduate has to demonstrate not only solid core subject knowledge, but also a set of additional 21st century skills. These include, among others, communication and critical thinking, as well as information and media literacies (Trilling & Fadel, 2012). It has been argued that 21st century skills should be taught across the curriculum in both secondary (Bergsma et al., 2007) and higher education (Christ, 2004). In addition to that, "it can be integrated into nearly any subject area" (Bergsma et al., 2007).

There is a growing demand for the ability to understand and create multimedia messages. We encounter media on-the-go, in our workplaces and at home; via TV, public display screens, phones, tablets, and computers. Elections and referendums are fought, won, and lost on media battlegrounds, and our social lives are increasingly entwined within media-rich social platforms. Public discourses play out in the comment sections of publications by powerful media organisations and many of us are now habitually representing our own lives in media forms (Aylett et al., 2016).

It is widely accepted that media is a kind of *language* (Hall, 1980). Like English or Mandarin, the language of media allows people to 'encode' and 'decode' meanings in various ways, from the highly *poetic* to the relatively *prosaic*. Like spoken or written languages, the language of the media requires certain *literacies* in order to encode and decode the meaning it represents, enabling people to both understand and engage critically with media (Aufderheide, 1993; Hobbs, 2010).

Furthermore, in the Web 2.0 era, where all of us gradually become *prosumers*, i.e. both producers and consumers of content (Mcloughlin & Lee, 2008), educators need to prepare their students to be capable producers. Production of multimedia messages is no longer a prerogative of artists and journalists. Modern technical professions require the ability to produce creative solutions, engaging portfolios and video presentations, and graduates must be equipped with these skills.

The SIGCSE (Special Interest Group in Computer Science Education) community is driving the innovation in teaching soft skills as part of CS education, with substantial efforts dedicated to improving student communication skills (Blume et al., 2009), fostering team building and collaboration (Soundarajan et al., 2015), as well as empowering students with entrepreneurial skills (McGee et al., 2016). However, there is little research on developing media literacy of CS students, and this work addresses this gap.

The following section presents an empirical study of how the SFC pedagogical approach facilitates the emergence of *media literacy skills as a by-product of collaborative video production* by third year undergraduate HCI students during their coursework on a core subject module. We recorded student behaviour through the use of a collaborative video production tool and analysed it with respect to the three key components of media literacy, namely: *access*, *analysis* and *production* of meaningful information. In addition to addressing the research question **RQ 4** of this thesis, this study contributes to learning design and classroom practice for HCI courses that aim to teach media literacy as a by-product of innovative pedagogy.

6.1.2 Data Collection and Analysis Methods

The data used in this study was collected during the first iteration of the Ubicomp course, in the academic year 2015-2016. The data set comprised both qualitative and quantitative data and consisted of Bootlegger metadata, student interviews (that were described and analysed in Chapter 4), and a questionnaire. The data collection was focused on studying the process of collaborative video creation that the students went through during the course. To be more specific, the data collection and analysis were aimed at investigating the process by which the students collaboratively created meaningful multimedia messages about their own learning. This helped to answer the following research questions:

RQ 2A: What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?

RQ 4: What transferable skills and literacies does the Self-Flipped Classroom pedagogical approach help to develop?

The collected quantitative data comprised system logs from the Bootlegger platform, which detailed video clip production and edit 'lifecycle' for all practical sessions. This data set included:

(i) *for each uploaded clip:* id, author, time of creation, length, practical session id, file path;

(ii) *for each created edit:* id, title, author, description, file path, time of creation, practical session id, number of clips used, clips ids.

Ubicomp - my Pi is alive! Final Shot List

	Filename	Shot By	Date / Time	Role	Shot (of)	Coverage	Length
	9-50-26.10_Step_1_Presenter_doing_something_wide_Raspberry_Pi_Module_leader.mp4 *635802626342108260_635802402261107090.mp4* *561b745a8e1d3de568548144*	Module leader	12/10/2015 9:50:26.10 am +01	Step 1	Presenter doing something wide ()	Raspberry Pi	00:00:02.6969632

Figure 6:1. An example of meta data for a clip created in Bootlegger.

Figure 6:1 illustrates how information for a single video clip created in the Bootlegger app was represented. The meta data says that the clip was created by the module leader for the first practical session called “my Pi is alive!” on 12th October 2015 at 9.50am; the module leader chose ‘Step 1’ as a predefined classification of the clip; the description of the action in the clip (also predefined in the template) says that it is about a ‘presenter doing something’ and it is captured in a ‘wide’ (i.e. landscape) angle shot; the clip’s main subject, or ‘coverage’, is Raspberry Pi; the ‘length’ of the clip is 2.697 seconds.

This provided a large quantitative data set, which was analysed using R, a programming language and environment for data analysis. Figure 6.2 shows an example data analysis program that was developed to find the correlation between the number of students who gave a video clip a ‘star’ (i.e. a ‘like’) and the number of times the clip was reused as part of derived video edits. This program follows a typical pattern comprising the following steps:

- Loading the raw dataset into R in the CSV (comma-separated values) format.
- Filtering out a target subset of data entries – in this case, simply removing the test and demonstration entries made by the module leader.
- Preparation of data entries for analysis: parsing textual time stamps into the time format supported by R, extracting the fields (columns) of interest from the entries, etc.
- Data analysis: aggregation, removal of duplicates, merging of partial results, sorting, application of standard data processing algorithms, such as ‘cor.test’ for computing the Pearson’s product-moment correlation and the corresponding p-value.
- Plotting and saving the data analysis results.

Other developed programs can be found in the Appendix B.3.

```r
# Load data
edits = read.csv("d:/data/bootlegger/edits.csv")

# Filter out entries authored by the module leader
edits = subset(edits, edit_made_by != module_leader)

# Parse times
edits$captured_at <- as.POSIXct(edits$captured_at, format="%d/%m/%Y %H:%M:%S")

# Extract two columns: clip_id and edit_created_by
user_clip = edits[,c("clip_id","edit_created_by")]

# Drop repeated rows (we don't want to count the same user of a clip twice)
uniq = unique(user_clip)

# Group rows with the same clip_id, computing the length of each group
popularity = aggregate(uniq["edit_created_by"], by=uniq["clip_id"], FUN=length)

# Compute a table with clip stars
clip_stars = subset(edits, select = c("clip_id", "stars"))
clip_stars = aggregate(clip_stars["stars"], by=clip_stars["clip_id"], FUN=max)

# Compute a table with clip creation times
clip_times = subset(edits, select = c("clip_id", "captured_at"))
clip_times = unique(clip_times[order(clip_times[,"captured_at"]),])

# Merge popularity and clip_stars tables
result = merge(merge(popularity, clip_stars), clip_times)

# Give the resulting column a more meaningful name
names(result)[2] <- "clip_popularity"

# Sort by decreasing popularity
sorted = result[order(-result[,"clip_popularity"]),]

# Plot clip popularity
plot(sorted[,c("clip_popularity")])

# Save result to a file
write.csv(result, file = "d:/data/bootlegger/clip-popularity.csv")

# Compute Pearson coefficient for the correlation between
# clip popularity and the number of stars = 0.6119259 (p-value < 2.2e-16)
cor.test(result$clip_popularity, result$stars, method="pearson")
```

Figure 6:2. Example of a data analysis program developed using the programming language R. This program was used to find correlation (measured using Pearson coefficient) between the popularity of a clip (i.e. the number of times it was reused in different video edits) and the number of stars given to it by the students. Other developed programs can be found in the Appendix B.3.

By separating data analysis programs from actual data sets (as opposed to, for example, doing analysis in an Excel spreadsheet with actual data), we were able to meet several goals: avoid contaminating the data set by destructive pre-processing steps or accidental edits, test the programs on small synthetic data sets to evaluate their functionality, benefit from peer review of the developed programs without disclosing the underlying data, and, last but not least, make sure the results of our research can be reproduced and/or validated on new data sets.

The qualitative set of the data included the following:

i. Interviews
ii. Analysis of student artefacts
iii. Survey

The interviews were semi-structured and conducted face to face (each about 30 minutes long) at the end of the course. The interviews focused on the students' general experience of the course and included questions about using digital media creation as a form of assessed coursework. The participation was voluntary, 8 out of 34 students (i.e. 24%) were recruited. The transcripts were analysed using inductive thematic analysis.

Our analysis of student-produced artefacts was based on: (i) a sample of the 10% of most popular video clips used in student edits (50 clips, with 6 to 18 uses each), and (ii) all 102 final video tutorials submitted for assessment, together with the corresponding marking criteria. These were also analysed using inductive thematic analysis.

A preliminary analysis of quantitative data and student artefacts revealed a number of questions that warranted further investigation. A questionnaire comprising 6 closed- and 2 open-ended questions was therefore created, tested, and distributed to the students electronically (using the online questionnaire service typeform.com). Two £10 vouchers were given out as an incentive for survey participation. 10 out of 34 students (i.e. 29%) responded. The questionnaire covered: the impact of open access to clips created by other students; the most important factors for clip choice for edits, and the students' perception of the overall outcome of the activity. The full survey questionnaire is provided in Appendix B.3. Some of the questions are listed below:

1. Did you ever create a video tutorial before Ubicomp 2015?
   a. Yes b. No c. Not sure
2. Did you like the idea of creating a video as part of a Computer Science course?
   a. Yes b. No c. Not sure
3. How did access to other people's (other teams') clips impact on how you made your own clips?

(For example, did watching clips of other students inspire you to do anything differently when making your own clips, or were there any examples of clips which inspired you to make something similar? Please, explain your answer.)

4. If you used other people's clips in your final edits why did you do so?
    a. I didn't capture any clips myself
    b. Clips made by other teams were of better quality
    c. Other students captured some clips that I didn't and I needed them for my edits
    d. Other reason (please, specify) ________
5. What was important for you when you were selecting clips for your final edits?

    (Please, name a few criteria you used, as well as others that you think are important. You can pick up more than one option as well as add your own to the list.)
    a. Visual quality (sharpness, lighting, stability/not shaky, etc.)
    b. Audio quality (clarity, volume level, etc.)
    c. Clip is precise
    d. Clip is long enough
    e. Clarity of explanation given by the narrator/right level of details
    f. The clip has something unique in it (new detail, charismatic presenter, best demonstration of the result, etc.)
    g. Other _____

The student responses to the survey's open-ended questions were analysed deductively, as we were looking to explain and further understand the issues that were found in the quantitative data. For example, after seeing a lot of video clip reuse in trial edits we wanted to understand the reasons why students reused other students' clips, and we also wanted to see if our speculations about those reasons for reuse were right. More specifically, we looked for the following themes: (i) ***positive or negative impact of having access to all clips created during the course;*** (ii) ***inspiration from watching other students' clips;*** (iii) ***indication of learning (both the subject content and additional skills).***

In the end, both the quantitative and qualitative data sets, and their analysis helped us to reconstruct the whole picture of student behaviour and their thinking during the process of the collaborative video creation, thereby contributing to answering the research question **RQ 2A** about students' attitudes and experiences. Furthermore, the discovered parallels between the students' behaviour and elements of the media literacy model helped us to see how exactly they developed their media literacy skills, thus addressing the **RQ 4.**

6.1.3 Results

There were 8 practical sessions during the course. In 6 of these sessions students were asked to document their work with the Raspberry Pi to generate footage for the tutorials. Students could choose any three practical sessions for their final submissions. The first three sessions, however, were significantly more popular with 88%, 82%, and 71% of students choosing them for their final submissions. The fact that the majority of students chose the same sessions contributed to a high degree of video clip sharing and facilitated student collaboration (e.g. 50% of students had their clips reused by other students 10 times and more). In total, 102 video tutorials were submitted. See Table 6:1 for an overview of the distribution of submissions across the 6 tutorial topics, as well as the corresponding totals of produced and reused clips.

Table 6:1. Summary of student contribution for each tutorial

Week	Tutorial	# of clips made	# of clip uses	# of submitted tutorials	% of total class
1	Pi is alive	177	745	30	88%
2	Proximity detector	221	699	28	82%
3	Context awareness	165	397	24	71%
4	Interactive surface	90	295	13	38%
5	Natural user interface	87	224	6	18%
6	Responsive LCD	66	62	1	3%
Total		**806**	**2422**	**102**	

By the end of the module, the students captured 806 clips; 657 were successfully uploaded to the system (some were lost due to connectivity issues). The total number of clips used for edits by unique users was 500. Many clips were used multiple times by same or different students, and the overall number of clip uses for all of the produced edits was 2,422.

All students enrolled in the module had successfully completed the video creation assignment. The average mark for the class was 19.9 out of 30 (66.3%, equivalent to 2.1 classification), and 13 out of 34 students earned a first-class mark (70% or above). The marking criteria for the assignment generally emphasised the clarity of video tutorials and their fit to the purpose. More specifically, to pass the assignment the students had to demonstrate in their tutorials all the necessary steps to complete a task in a logical order and with enough details for another student to follow the tutorial and achieve the same result. Marking criteria also put emphasis on evident consideration of the learner's needs, such as clarity, tone, and pace of narration; variety and appropriates of the use of graphics and other visuals; demonstration of creativity to encourage interest and to maintain engagement in the video tutorial. See Appendix B.1 for a complete list of marking criteria for this video coursework. Based on the fact that all of the submitted videos were assessed above the "fail" category or, in other words, even the weakest submissions delivered the intended message to a satisfactory degree, we consider that all of the student artefacts were *meaningful multimedia messages*.

6.1.4 Media Literacy Model vs Student Behaviour

The research objective of this study was to investigate *the process by which students collaboratively create meaningful multimedia messages about their own learning.* To do that, we use Aufderheide's definition of media literacy as "the ability of a citizen to *access, analyse,* and *produce* information for specific outcomes" (Aufderheide, 1993), as well as the description of its three key components, presented and discussed in detail in Chapter 2, as a framework for classifying our findings into categories of student behaviour. Below we describe how students *access*, *analyse* and *produce* a media message and demonstrate the necessary literacies using examples from the collected data.

a) Ability to access

Access is the ability to physically access the information by skilfully using media and technology tools, and sharing appropriate and relevant information with others (Hobbs, 2010). In terms of the student interactions with Bootlegger, this is the ability to use mobile phones and PCs with the Bootlegger application, and to access the clips stored in the cloud that were created with Bootlegger.

We first look in detail at the behaviour that students demonstrated and then translate it to the corresponding elements of media literacy.

Student behaviour:

All students in the course successfully used the Bootlegger mobile and online applications with shot planning and templates for shooting the clips that document the process of their work with the Raspberry Pis. The students were also able to access and watch all of the clips uploaded into the Bootlegger system and participate in sharing the clips with others.

Activity outcome:

With regards to the outcome of the activity, this means that, by possessing the required technology (mobile phones and PCs), being able to download and install the tool (Bootlegger), and agreeing to do so, the students demonstrated their "ability to physically access information". Moreover, 5 of 8 interview and 7 of 10 survey respondents said that they liked the idea of using video for assessments, and 4 students said they preferred video tutorials to written reports, which further demonstrated their acceptability of the method and the motivation to use it again in future.

b) Ability to analyse

Analyse/Decode is the ability to decode and comprehend information carried by media messages (Churchill, 2010; Livingstone & Thumim, 2003); interpret and evaluate media messages, analyse their quality, accuracy, reliability, and point of view, while considering potential effects or consequences of messages (Hobbs, 2010; Aufderheide, 1993). In terms of interactions with Bootlegger this translates to: (i) decoding the clips from the cloud to interpret their meaning and decide what they are good for; and (ii) evaluating the quality of the clips to select the best ones for the final video.

Student behaviour:

Students decoded the information carried by clips in Bootlegger to determine which clips they could use in their own tutorials.

Activity outcome:

The Bootlegger platform allows the user to sort clips connected with a shot by the time of creation, author, and other preselected characteristics, such as association of the clip with a particular step, shot overlay, or subject focus; it also has a thumbnail preview with metadata. Furthermore, students had an option to 'star' (or 'like') clips when viewing and selecting them in the platform. 166 clips received at least one star. 45 clips got more than one star, and 1 clip got 6 stars which was the maximum. The Pearson coefficient for the correlation between the clip popularity and the number of stars is 0.61 ($N=166$, $p\text{-value} < 2.2\times10^{-16}$), which is a strong correlation for social sciences and studies of human behaviour (Shortell, 2001). In other words, the more starts the students gave to a video clip the more likely this clip was reused in the students' video edits. Giving stars to the clips was one of the steps in the analysis of the pre-production material – the students chose the clips that were fitting for the intended purpose and were of adequate quality to be used in the final edits. See Figure 6:3 for the plot illustrating this correlation. The Pearson coefficient and data for the plot were computed by the program presented in Figure 6:2; the plot data was further processed in Excel to obtain the final plot.

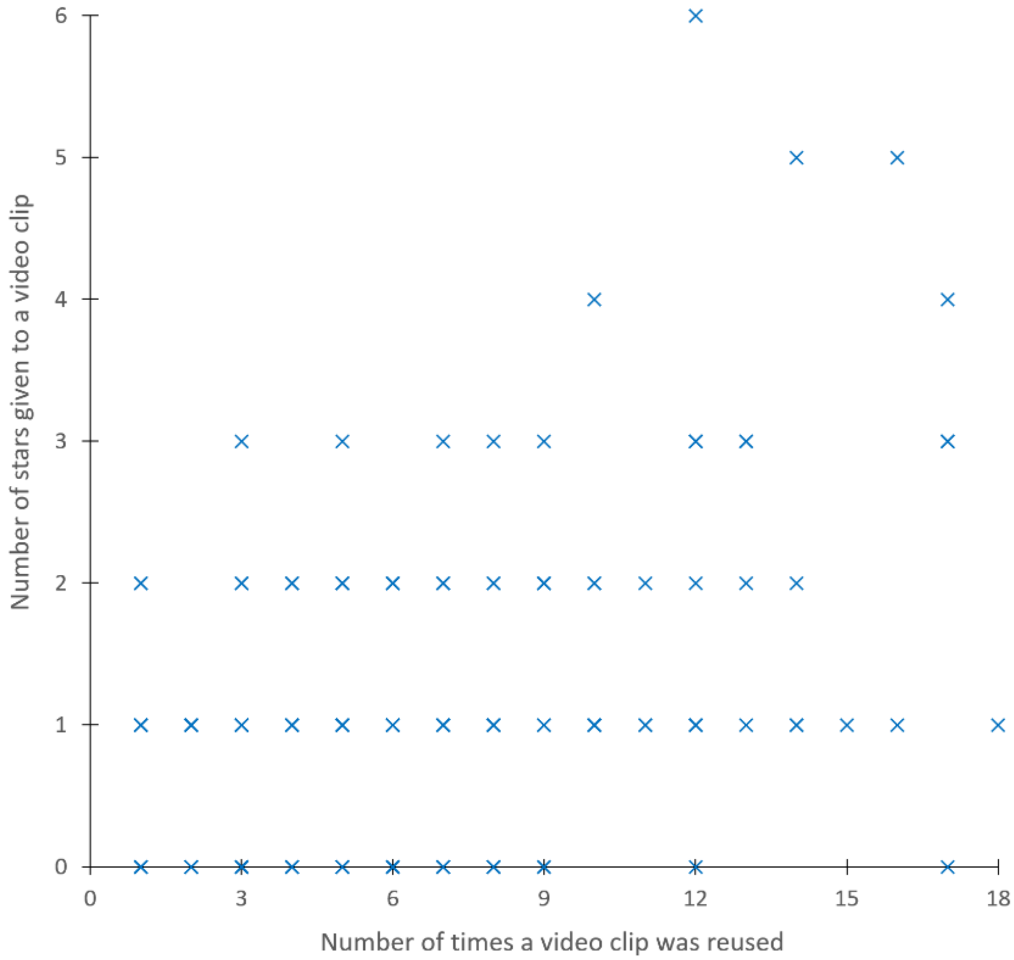

Figure 6:3. Plot of the correlation between the number if stars given to a video clip and the number of times it was reused in video edits. Note the empty top left corner, which emphasises the correlation. The corresponding Pearson coefficient is 0.61 (N=166, p-value < 2.2×10^{-16}). See Figure 6:2 for the data analysis program used to compute the Pearson coefficient and generate data for the plot.

The Bootlegger log data demonstrates that all students, even those whose final videos contained only their own clips, attempted to create edits that used clips made by other students. This was also confirmed by student answers in the interviews and survey, for example:

> *"I first looked at my own clips, as I just wanted to use my own resources. Only when I didn't find something in my clips I went looking for others' clips. I also did use Lea's 'title' clips because they're good, she just nailed it."*

(Here the actual name was changed to "Lea" to maintain anonymity.)

The qualitative analysis of 10% of the most popular video clips used in student edits gave us a list of the most common features or factors preferred by the students, including genre and cinematic qualities apparent in the clips. We took this further and asked survey participants to rate these factors with regards to their importance for the students' choice of the clip. The obtained results are illustrated in Figure 6:4.

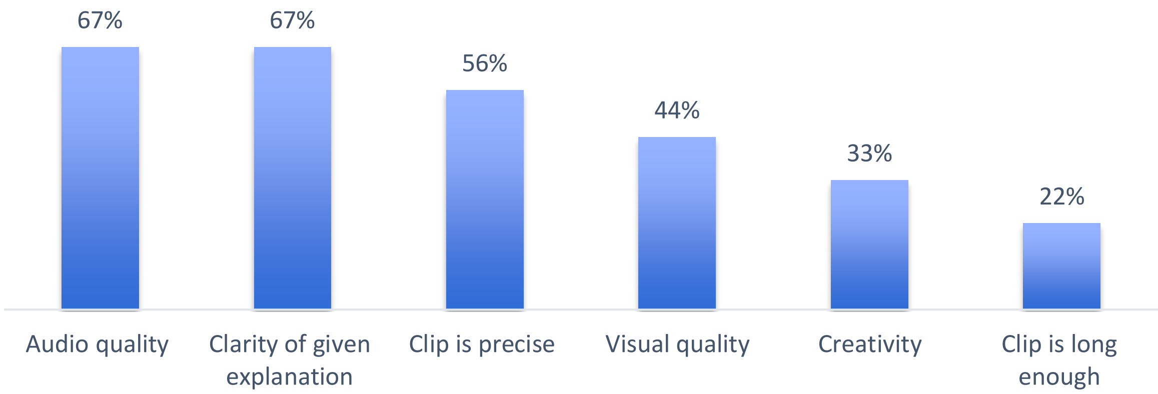

Figure 6:4. The most important factors for selecting video clips for final edits according to the student survey (the factors are labelled with percentage of survey responses).

Further analysis of the most used clips also revealed that the following clip genres were most popular: (1) title; (2) close up, connecting things; (3) code explanation; (4) head shot (introduction); (5) head shot (explanation); (6) demonstrating how something is working; (7) code and output demonstration; (8) graph explanation, close up; (9) objects, details, close up. See Figure 6:5 for a comparison between the number of popular clips per genre and the number of their total uses among the 10% of the most used clips. As an example, 23 clips in the genre 'title' were used 271 times in total.

By analysing the lengths and contents of the clips, we also found that 64% of most popular clips were short and concise, and focused on only one thing (common examples were title screens for tutorial steps, as well as basic steps like connecting something to the Pi), which suggests that *elementary clips* were more reusable. In retrospect, this is unsurprising: much like elementary functions are most reusable in the context of software development, elementary clips are most reusable in the context of collaborative video making. This highlights the students' ability to analyse video clips, decode their messages, and evaluate their suitability for incorporating into their edits.

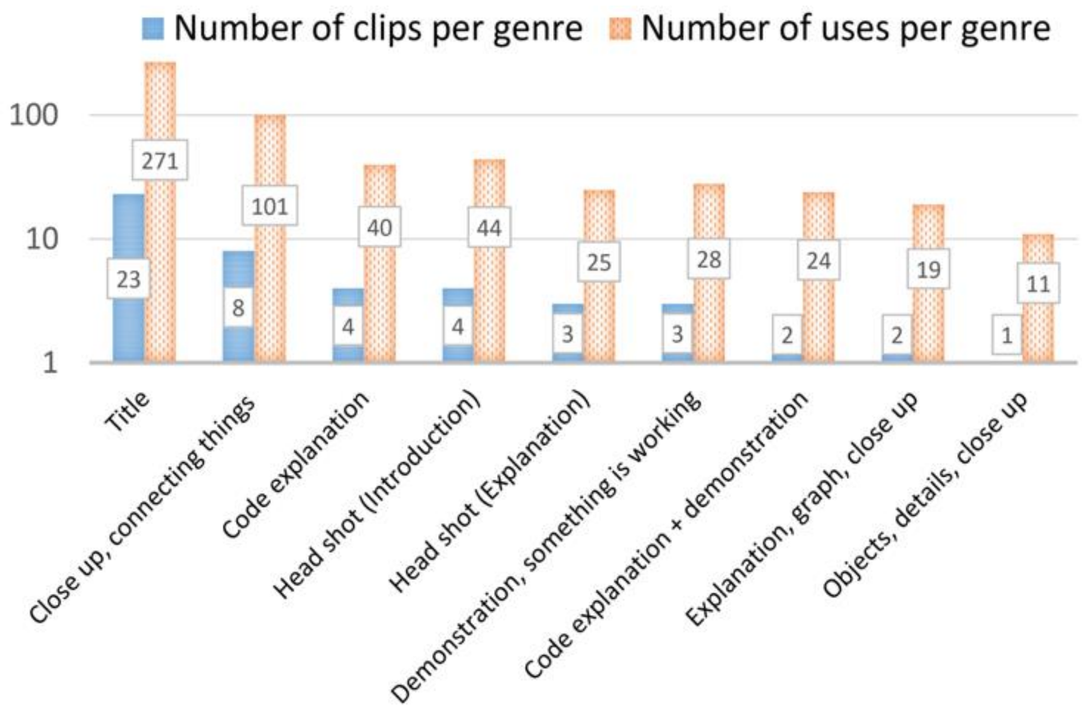

Figure 6:5. Clip genres (the horizontal axis), the number of clips per genre (blue fully filled vertical bars), and the number of total clip uses per genre (orange dotted vertical bars), as seen from the analysis of 50 most popular clips.

c) Ability to produce

Produce/Encode is the ability to create content with creativity and confidence in self-expression, encoding the message with the awareness of the purpose, audience and composition techniques (Hobbs, 2010; Aufderheide, 1993; Churchill, 2010). In terms of interactions with Bootlegger, this translates to: (i) at the clip level, generation of clips documenting each step of student work; and (ii) at the edit level, editing the clips into a film (tutorial) in order to create a meaningful narrative for a specific purpose.

Student behaviour:

Video production through Bootlegger consisted of two steps:

At the clip level: students recorded clips showing the steps of their work. They were given some tips in the forms of the assignment brief, Bootlegger templates (suggested steps of the tutorial, clip lengths, a collection of possible shot overlays), and an example tutorial prepared by the instructor. They were free to experiment and demonstrate creativity.

At the edit level: the recorded clips needed to be composed into a tutorial, creating a meaningful narrative for: (i) demonstration of learning outcomes of the course; and (ii) instruction of other students.

Activity outcome:

Although students were tasked to produce clips during the class time, nearly half of the interview and survey respondents admitted that they were unhappy with the level of quality of the recorded clips and spent additional time after the classes to reshoot and improve most of the clips. By analysing time stamps of the clips uploaded to the cloud, we can see that, for example, many clips related to Practical 1 were in fact shot substantially later in the semester, as can be seen in Figure 6:6. In the interview and survey responses, the students also admitted that attempts to create an edit made them reconsider which clips had to be recorded. One student explained in the interview:

> *"When we actually did that first video, like maybe a couple of weeks before the deadline, we kind of realised that there is all this content that we needed that we haven't actually been recording for all of the weeks, so in the end we had to go back and basically just record everything from scratch again."*

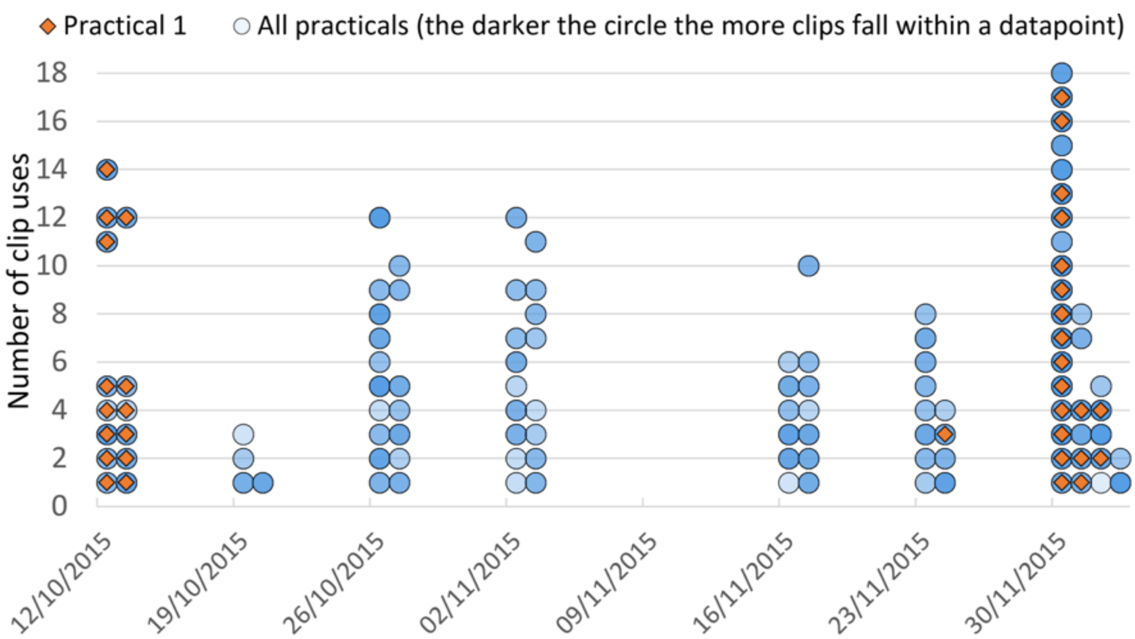

Figure 6:6. The number of clip uses (the vertical axis) versus the date of its creation within the production timeline of the course (the horizontal axis).

The students further acknowledged that access to the clips shot by their peers had a positive impact on their video creation (8 survey respondents), inspired them, and made them rethink their own clips (6 respondents). The quotes below particularly highlight this:

> *"It got me thinking about things I never considered before and also on ways to improve it."*
>
> *"On seeing other's clips, I realized mine featured only code and the Pi, however some students had introduced the project and gave explanations with the camera focused on themselves. I thought this was a much more personal and friendly approach so I incorporated this into my own videos."*

9 survey participants said they used clips shot by others because they did not capture some of the necessary clips themselves. Also, 4 respondents admitted that clips made by others were of better quality. On the other hand, 6 respondents preferred to use their own clips for the final edits as they thought they were of better quality. Finally, 3 respondents said they wanted to use only their own clips as they were shot in the same style, so the edits would look homogeneous.

The above demonstrates the students' *ability to produce* and their awareness of the video content, quality and composition techniques, as well as the development of this ability by learning from their peers through the use of a collaborative video creation tool.

6.1.5 Discussion

We have explored the process of media message creation in student-produced content through a novel framework of media literacy. In doing so, we observed each of the three main components of media literacy (*access*, *analyse* and *create*), in the process of student learning to engage in the practice of producing a video. Like Weilenmann *et al.* (Weilenmann et al., 2014), we assume that the demonstration of these skills is a candidate step for the manifestation of an emerging media literacy trajectory.

In addition, we made the following observations about student behaviour:

i. The students realised certain problems with their video footage (such as the lack of different perspectives or poor audio quality) only when they encountered them as part of the final video editing. Thus, student media literacy emerged and developed through the process, prompting them to redo the clips or to search for alternatives among the clips produced by their peers.

In their essence, the production activities at the clip and edit levels are very different: the former is to record what is happening here and now; the latter is to construct a storyline where each component/clip is in the right place and appropriate for the whole story. While in everyday life many of us create clip-level videos (recording events that are happening around us and catch our attention or interest), not everyone is familiar with video editing techniques, where an author has to bear in mind the ultimate purpose and hence the content and shape of the final product (Weilenmann et al., 2014). So, the fact that our students had to redo most of their recordings after trying to construct the final edits suggests that their media literacy emerged on the go.

ii. The fact that the students moved back and forth between the media literacy components when they decided to redo the video to improve it, implies that the process of media message creation is neither linear nor cyclic. We believe that the three main components are interdependent and may occur in different sequences, which is an important consideration for updated media literacy models. A variant of an updated media literacy model is illustrated in Figure 6:7 below:

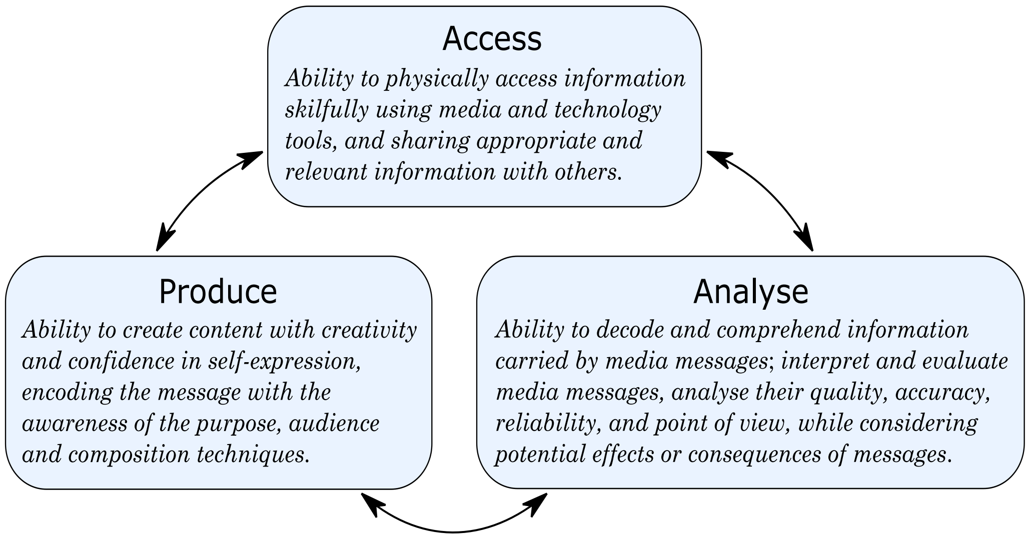

Figure 6:7. An updated media literacy model, where the three media literacy components are part of an iterative process that is neither linear nor cyclic.

iii. Students took advantage of the opportunity to see contributions uploaded by the peers. They learned from each other, as evidenced by their clip reshooting after watching clips by others (seen from Bootlegger log data and confirmed by the interviews and survey). The students also developed an understanding of *reusability of media components* with such factors as the clip authorship, its visual and audio quality, as well as clip genre, and time of creation.

iv. The collaborative environment of Bootlegger in its nature is similar to crowdsourcing, e.g. outsourcing jobs/tasks to everyday people/crowd (Howe, 2006), which is familiar to many CS practitioners. Thus, students looking at and selecting clips from the cloud have demonstrated the pattern of *deconstruction*, where the more elementary component is, the easier it is to reuse it. Such clips as 'title' and 'connecting things' are less personal, more elementary, and have limited capacity for misconception or presentation of a wrong point of view. Hence, they were popular for reuse among the students. On the other hand, 'intro' and 'demo' clips display more individuality and present deeper levels of information, so there was a greater risk of being misinterpreted or provide incorrect details, thus most students preferred to shoot these clips themselves.

6.1.6 Summary and Motivation for the Second Study

This section presented a study that demonstrates that the creation phase of the SFC approach helps students to develop a skill of meaningful media message creation, which is an indication of media literacy, as a by-product of video coursework production. This study shows how the use of mobile collaborative video production technology by non-professionals can help them learn to create meaningful media messages with little scaffolding.

Now that we have seen that students *can* create meaningful media messages, our next step is to look at *how* they do it with regards to fair collaboration and attribution. In particular, the use of Bootlegger and a discussion forum allowed us to investigate student collaboration in fine detail and identify different patterns of fair use and attribution behaviour when working with different types of media: video and text.

6.2 Collaboration and Attribution

Media literacy is a prerequisite for creation of meaningful artefacts. Although the students in both of the case studies (A and B, presented in Chapters 4 and 5, respectively) demonstrated their ability to create meaningful media artefacts, it was worth looking at the collaborative process of artefact creation in the first part of Case Study A more closely, where the students were tasked to create two types of the artefacts: videos (tutorials) and texts (blog posts). In the previous section, we looked only at videos. In this section, we also include texts, which leads us to finding a difference in student behaviour when authoring different types of media.

This study is based on the data collected in the year 2016-2017. While I led this study, I acknowledge help and insights of my collaborators and co-authors, Ghaith Tarawneh, Haneen

Qarabash, and Madeline Balaam, on the corresponding paper "Collaborative Content Creation: Impact of Media Type on Author Behaviour" (Vasilchenko, Tarawneh, et al., 2018), and thereby I use the pronoun "we" throughout the rest of the section.

6.2.1 Introduction

Digital media has led to the emergence of *participatory culture* where people are habitually "shaping, sharing, reframing, and remixing media content" instead of consuming pre-constructed messages (Jenkins et al., 2013). This has made it important for university students to acquire soft skills such as communication, collaboration and digital literacies on top of solid core subject knowledge. To encourage this development, modern education incorporates elements of collaborative learning with the use of social technologies that promote peer-learning and community building along with improvement of learning outcomes (Schroeder et al., 2010). However, this also leads to blurring boundaries between acceptable (and/or encouraged) collaboration and academic misconduct (Simon & Sheard, 2015). This is similar to the issues of copyright infringement for the communities of online content creators and "remixers", which are attracting interest of HCI and CSCW researchers, e.g. (Fiesler & Bruckman, 2014; Fiesler et al., 2016; Faklaris & Hook, 2017).

Understanding student collaborative behaviour can therefore inform the design of collaborative pedagogies to exploit their full potential while steering students away from copyright infringement and plagiarism. This section presents an investigation of the relationship between the media type and student collaboration and attribution patterns during collaborative content creation. We run similarity analyses on text and video artefacts submitted by students as part of collaborative exercises in an undergraduate HCI module. Our main finding is that the same cohort of students (i) demonstrated different remixing behaviour when authoring text compared to video content, and (ii) was significantly more likely to attribute non-original content to the sources when the content was produced not by a peer student. Our results suggest that media type has a considerable impact on student collaborative behaviour, and that students require more clarification on what is fair use and copyright rules within collaborative environment.

6.2.2 Context and Data

The data used in this study was collected during the second iteration of the Ubicomp course, in the academic year 2016-2017. The data was analysed under the umbrella of **RQ 4** with the following specific focuses in mind:

1) To explore the extent and patterns of student collaboration (reuse and remix of content) when working with different types of media.

2) To investigate whether there is any difference in student behaviour with regards to fair use and attribution when working with different types of media.

The data set included both qualitative and quantitative data. The first part of quantitative data included system logs from the used video production tool (Bootlegger) which detailed the clip production and edit 'life cycle' for all practical sessions, as detailed below. The second part of quantitative data comprised 'view count' data from the online forum (visitors per page) and text content from both the discussion forum and the final blog posts of the students.

Specifically, the quantitative data included the *meta data* from the collaborative video creation tool Bootlegger, and the *words/text* from the discussion forum threads and students' blog posts.

The meta data obtained from Bootlegger, was related to:

- 1566 clips shot in total;
- 614 clip uses (including repetition);
- 140 final videos submitted for assessment.

In total, 36 (out of 48) students contributed to the clip creation in the system, i.e. uploaded at least one clip.

Similarly to the previous study, the analysed meta data comprised: (i) for each uploaded clip: id, author, time of creation, length, practical session id, and path to the video artefact; (ii) for each created edit: id, name, author, description, path, time of creation, practical session id, number of clips used, and clips ids. This data was analysed quantitatively using the programming language R (see Chapter 6, Section 6.1 for further details).

Bootlegger had performance issues, so not all students in the class preferred to use it; some chose to use a different tool, in which case we did not have access to their data. Note however, that even these students had access to the overall Bootlegger pool of video clips, and opportunity to learn from it.

To analyse the text data quantitatively we treated all words that the students wrote in their comments in the discussion forum, as well as their blog posts submitted for assessment, as *elementary units of analysis*. In order to quantify similarities in these texts, we used a custom software tool (whose development was led by Ghaith Tarawneh, the second co-author on the corresponding paper) to compute a correlation between pairs of student-produced text artefacts, for example a blog post created by one student and a forum thread to which the whole cohort contributed. This correlation was computed by counting the number of N-word phrases, or so-called "N-grams", which co-occurred in each pair of student submissions. That phrases that were double-quoted or appropriately attributed to their sources by other means were excluded from these co-occurrence counts.

Qualitative data comprised student interviews and analysis of the student artefacts.

The interviews were semi-structured, face to face, included 9 participants, and were 30 minutes long (see Chapter 4 for further details). In addition to the questions mentioned in Chapter 4, the interview schedule included a section particularly focused on student attitudes to and experiences of content reuse in the process of their collaborative work on the course assignments. This part of the interview comprised of the following questions:

1. Did you use clips created by other students in your edits? If yes, did you give them credits for it? (Did you think about giving credits to the authors?)
2. Did you use ideas articulated by other students in the forum in your blog post? If yes, did you reference them?
3. How did (or would) you feel if other students used your clips and ideas for their work?
4. What do you think is ethical and what is not in this context?
5. What is your understanding of plagiarism and fair use?
6. Do you think editing other students clips into a new edit is plagiarism?
7. Do you think marks we gave for this assignment were fair?

The interviews were analysed using inductive analysis, following the same procedure as described earlier in Chapter 4.

Student artefacts (both videos and texts) were analysed by looking at: (i) similarities between materials created by different students; (ii) remixing of clips shot by different authors; (iii) use of other media (music, pictures, etc., not produced in the class); (iv) similarities between the submitted artefacts and shared materials (clips and forum discussions); and, finally, (v) attribution patterns.

For example, when studying the video artefacts, we were looking at the overall amount and patterns of the reuse of clips, that is: what kind of clips were most (re)used; whether there were authors that got reused more than others; what were the attribution patterns (how much of the content produced by others was reused and how much of it was properly attributed).

When studying the text artefacts, which consisted of discussion forum threads and the blog posts submitted for assessment, we were looking at: whether there was a transfer of content from the discussion forum posts to the blogs; what type of content was transferred most frequently (examples, references, opinions); whether there were authors that got reused a lot more than others; what were the attribution patterns (again, how much of the content produced by others was reused and how much of it was properly attributed).

6.2.3 Findings and Discussion

a) Collaboration with peers

Analysis of the student submissions revealed significant amount of overlap in the content, as described below, separately for the video and text artefacts.

Video

We found a lot of visual similarities in the submitted videos – see Figure 6:8 for a representative example. In addition to manual visual inspection, we had access to the clip reuse meta data from Bootlegger, which allowed us to automatically trace clip remixing within the cohort. In particular, the meta data revealed that clips authored by 17 students were used 614 times for trial and final edits by all 36 students in the system (while there were 48 students overall, only 36 students submitted their clips through Bootlegger). In the interviews, students said they had informal discussions with their classmates on how to approach the tasks, and they liked to see what other students were doing.

On the one hand, the above findings are positive as they demonstrate collaboration and peer-learning within the cohort. However, on the other hand, there were a small number of cases where students clearly crossed the line, twisting the collaborative online environment into a convenient tool for plagiarism. For example, two students submitted video artefacts consisting solely from clips shot by other students.

It was not possible for us to trace the origin of all of the similarities in videos, i.e. identify the authors who first came up with a particular concept, like the graphical layout represented in the Figure 6:8. However, we could infer from student interviews that students did see the work of others among the shared clips and then often replicated the ideas in their own videos.

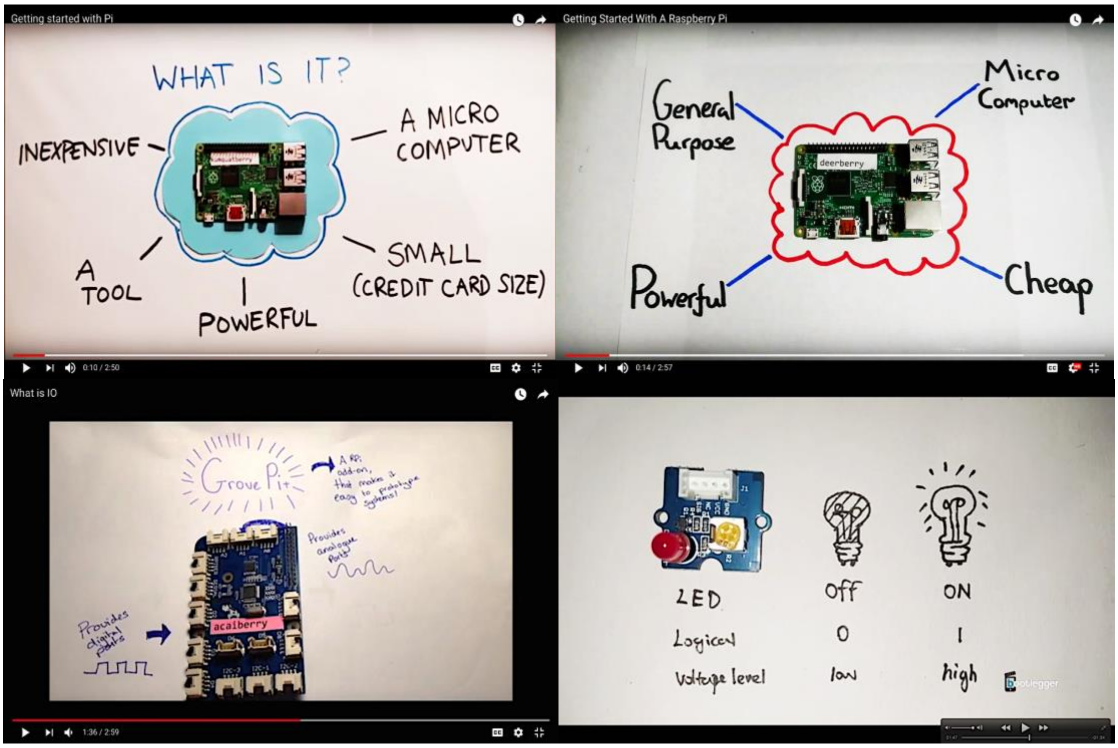

Figure 6:8. Screenshots demonstrating similarities in videos created by 4 different students. At least 6 students have used the same style: drawing on a board or sheet of paper around Pi and peripherals and hovered with their camera to show them in their videos.

Text

The 'view count' data from the online forum suggest that students regularly visited the forum. There was a high amount of activity in each forum thread, with 37 comments on average. One should keep in mind, however, that students were rewarded for contributions to forum discussions in the overall course assessment (up to 10% of the total mark). We found that most of the activity was "shallow", i.e. engaging mostly with the original blog post, posted by the instructor, but not with existing responses/comments to it; "deep" discussions between the students were uncommon, with the average number of only 2.4 replies to existing comments per blog post (among the overall average of 37 comments per blog post).

In the interviews, students said they liked sharing things in the forum and reading the discussions each week in preparation for the class. Moreover, they stated that they looked at the relevant forum thread when working on their own blog posts. Our manual comparison of students' final submissions with the forum discussions reveals a lot of similarities between the examples and ideas discussed in the forum and those presented in the blogs by different authors.

However, when we tried to quantify these similarities, using a custom software tool to count N-word phrases or "N-grams" that co-occurred in each pair of student submissions, we did not find any evidence of significant text re-use. This suggests that students were mainly authoring original text (that is, the phrasing was not repeated, even though the meanings often were) while attributing non-authored text segments to the sources.

b) Attribution

We did not find any academic misconduct with regards to attributing *external sources* in both types of studied media. Student gave credits to literature, music, images, etc., used in their works. However, they did not credit *internal sources*, i.e. their peers, for anything, except for one case where a student submitted a remix of video clips taken entirely from another student. Neither in video nor in text artefacts students felt necessary to acknowledge their peers for original ideas, opinions, examples, methods, etc.

In the interviews, students mentioned that they believed it was fair to take someone's idea from the forum and present it in own words in the blog post. By rephrasing the "borrowed" content in their text, they were able to make it sound original, and indeed fool the N-gram analysis tool. The same "rephrasing approach", that is taking someone's idea and using it in making a new video, appeared to be much harder with the video content. So, while some students did try to replicate other students' ideas in their new videos, some students just used the ready clips shot by the others. We therefore conclude that video artefacts can be more suitable in the SFC settings that focus on accurate tracing of the reuse and attribution of ideas.

c) Sense of ownership

Data from the interviews suggest that authoring students tend to have the sense of ownership towards their creations. Several interview participants mentioned that even when they saw a feature they liked in the works of others, they did not just copy it but wanted to redo their own work in order to include that feature.

When asked about their attitude to being copied by others, students said they would be disappointed if those who copied their work would receive the same course mark. One student said in the interview:

> *"I didn't come across using someone else's work before. It kind of felt like: Oh, I've put lots of time in it, worked really hard on this, and someone could just take it and submit the same thing and get the same mark. That felt kind of weird and unfair."*

There is a basis here to discuss the judgment of the value in co-creation. Should it be worth the same: to create an original piece of work from scratch, and to remix several pieces of works by other authors into a new one? Search, selection, and remix – an editorial choice – is a form of creativity on its own.

6.2.4 Summary

Referring back to the focus of this part of the study (outlined at the outset of Section 6.2.2), we can say: (i) the students demonstrated a significant degree of collaboration when working with both text and video content; (ii) we found discrepancies in student behaviour with regards to remixing different types of sources and different media types of peer-generated content; (iii) there is a need for additional instruction on fair use and attribution when working with peer-generated content of any type. This highlights the importance of considering different media types when designing a course based on collaborative content creation, as well as addressing the issues of academic integrity and copyright infringement.

Additionally, we see an opportunity for design of new HCI technology for helping students learn fair use and attribution, and stimulate good attribution practices by, for instance, automating the search and crediting of peer contributions within used social media platforms.

More research is required to further investigate why students credit external sources but choose not to credit their peers' contributions, as well as to understand student attitude towards fair use for different media types.

In contrast to the media literacy study (Chapter 6.1), the findings presented in this section do not explicitly show the development of fair use and appropriate attribution skills. We can hypothesise that the student exposure to such learning activities and a due guidance from the instructors can help the students to become accustomed to fair reuse and attribution behaviour. Proving this research hypothesis is an opportunity for future research.

6.3 Chapter Summary

This chapter presented two studies aimed at investigating transferable skills in the SFC context. These studies have shown that the collaborative SFC environment provides a rich ground for:

- In the case of students, developing transferable skills, such as media literacy, and
- In the case of instructors, analysing the development of transferable skills and student collaboration and attribution patterns by equipping the tools used for content creation and reuse with mechanisms for tracing the propagation of ideas.

To answer the **RQ 4** "*What transferable skills and literacies does the Self-Flipped Classroom pedagogical approach help to develop?",* I argue that SFC helps to develop a wide range of skills that are related to collaboration and content creation in general. The findings about media literacy, attribution, and fair use, presented above, are only a small set of examples, which was possible to investigate as part of a PhD project, and which was encouraged by the availability of the used tools. The student and instructor interview results further indicate the potential development of other skills such as: creativity (e.g. some students created excellent videos and made prototypes for their projects because of the need to film them); various digital literacies (e.g. many students did not know how to make instructional videos using their smartphones before the course, nor how to edit the footage into a final video); social skills like work-place interviewing (the SFC is flexible enough to facilitate the development of such course-specific skills); critical thinking (e.g. when selecting peer-produced video clips and evaluating them), and reflective learning (e.g. when students learned from peer-produces materials and unconsciously compared them to their own materials). These transferable skills were not directly measured in the presented case studies, but they were consistently mentioned by the participants in the interviews, which motivates further discussion as part of the next chapter.

Chapter 7. Discussion

This chapter presents a critical analysis of the findings described in Chapters 4, 5 and 6. It also synthesises answers to the research questions **RQ 2** through **RQ 5**, which guided testing and evaluation of the SFC approach in practical settings.

More specifically, in Section 7.1, I will use the data presented in the earlier chapters to address **RQ 2** and **RQ 3**. I will also continue the discussion on transferable skills promoted by the SFC to extend the answer to **RQ 4** presented in Chapter 6. Taken together, **RQ 2** and **RQ 3**, with all their sub-questions, and **RQ 4** will me help to paint a comprehensive picture of *the perceived impact of the Self-Flipped Classroom pedagogical approach* from the perspectives of both students and instructors. Then, in Section 7.2, I will discuss the final research question of this thesis: **RQ 5**. This will help me to summarise the research presented in this thesis by comparing and contrasting the two variants of Self-Flipped Classroom: *Enclosed* and *Distributed SFCs*. Sections 7.3 and 7.4 will complete this chapter by discussing a few considerations for SFC implementation, and by drawing implications for pedagogy and technology design to support collaborative content creation for blended learning courses.

7.1 Self-Flipped Classroom Impact

This section takes a look back at the data presented in the Chapters 4, 5, and 6 in order to conceptualise the experiences that the students and instructors went through as part of the SFC teaching and learning. This helps me to articulate the impact that the SFC had on them.

7.1.1 Impact on Students

I discuss SFC's impact on students through deconstruction of their experiences into the roles they take in the SFC. I identify four distinctive roles: *creators*, *collaborators*, *communicators*, and *learners*. By assuming each role, students develop corresponding skills. For example, by being creators, students acquire and develop the skills of creation (e.g. of meaningful media messages and of artefacts that are usable for teaching others and for inclusion into learning portfolios). All of the identified roles correspond to important transferrable skills that modern university graduates are expected to develop. I therefore continue to answer **RQ 4**:

RQ 4: *What transferable skills and literacies does the Self-Flipped Classroom pedagogical approach help to develop?*

The case studies identified different roles that students took during the Self-Flipped Classroom courses. These roles are indicators for students gaining the lifelong learning skills associated with each role. This discussion is illustrated with anonymised quotes from student interviews and responses to questionnaires from both case studies presented in this thesis. The Venn diagram in Figure 7:1 illustrates the relationship between the identified roles/skills.

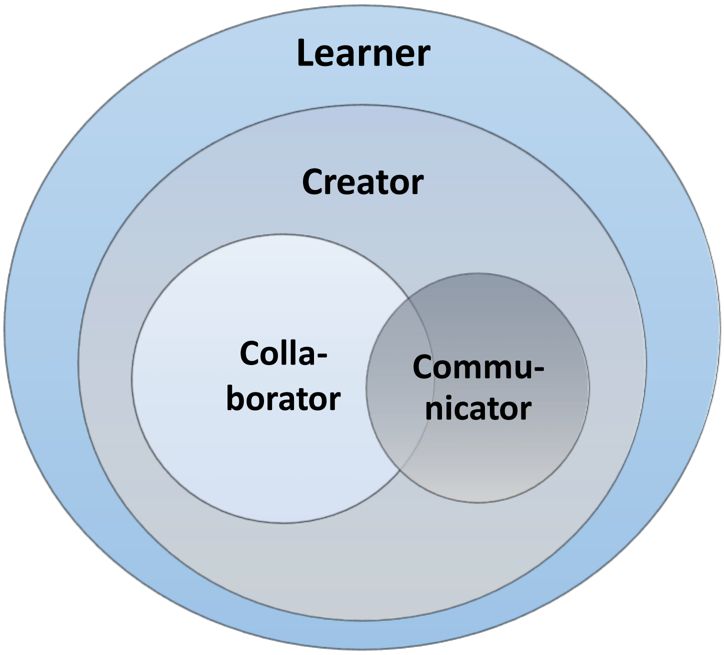

Figure 7:1. Student roles in Self-Flipped Classroom

As part of learning artefact *creation*, SFC students *collaborate* with each other on various levels and develop skills of *communication* (going beyond traditional essay writing or oral presentation). All of these activities eventually result in multi-layered *learning*: subject learning, reflective learning, and soft skills learning.

Below, I look into these roles/skills in detail.

a) Students as creators

As highlighted by the related work and theoretical background (Chapter 2, Section 2.2.2), in a contribution-oriented pedagogical approach content creation by the students is just as important as content consumption (Hamer et al., 2008; Falkner & Falkner, 2012; Collis & Copsey, 2005). Yet, today's students are still unaccustomed to being responsible for gathering or creation of the learning materials intended to be studied by their peers or future students. The findings of this research show that students have mixed attitudes towards artifact creation, especially when it comes to non-traditional types of coursework, such as video making in a Computer Science module. Some students feel that there is too much focus on the creative part in such coursework, and do not really see the connection to their learning of the topic. One student from the Enclosed Self-Flip case study gave following comment in the course evaluation survey when asked "What can be improved in the course":

> *"The group and individual work aren't focused on the course contents but rather on how to conduct an interview, how to create a movie, how to write a report, not about complex IT systems in large organizations."*

Such attitude demonstrates that this student clearly did not understand the intended learning outcomes of the coursework and how the creative or non-traditional side of the coursework connects to the technical content of the course. In contrast, the survey conducted during the Ubicomp 2017/2018 course showed that the majority of the students liked the "idea of creating learning materials for someone else as part of their own learning". Furthermore, the students showed their preference for multimedia materials creation. Students in general, despite some having difficulties with the initial understanding of what exactly was required from them, accepted the idea of video making very positively. The following quote illustrate this:

> *"I like the idea; the concept was good. It was like: "Hey, here's the thing we did. Hey, it turned on. Hey, its flashing. Hey, it's all singing, it's all dancing, look what we made this Pi do!" That's cool, I love that idea!"*

It is important to note that there was a large variation in the effort that students put in production of their artefacts in both case studies. Some students spent a lot of time preparing the artifact by reading up on related work, making a prototype, mastering video editing software, etc., whereas others did as little as possible. This was reflected in the interviews and surveys: in particular, some SFC students at Uppsala University described that they had spent too much time on the course compared to the course credits gained, whereas others described that they had hardly spent any time at all. This implies that some students saw the value of what they were doing as part of their learning and artefact creation, while some other students did not. This attitude to creation and quality of the created materials had a direct effect on learning of the creators and their peers. Instructors who implement SFC in their practice need to bear in mind such potential predisposition to non-traditional coursework and invest additional time and effort to explain the value of the planned learning activities to students.

b) Students as collaborators

As argued by Gillmor (2010), becoming a creator today means becoming a collaborator too, as most of the contemporary tools for creation are inherently collaborative. Besides, today one of the first items on the agenda of almost any newly-hired graduate is learning how to effectively collaborate within the team. So, when we are equipping the students with professional lifelong learning skills, an important part should be devoted to the skill of collaboration. Equally, the ability to collaborate during artefact creation is an important factor in the SFC setting.

It is worth noting that students also need to learn how to work individually, and some actually prefer that. Therefore, a combination of collaborative and individual tasks for SFC coursework was found to be the most preferable. After the first iteration of the SFC module at Newcastle University, students' attitude towards group work on their coursework was mixed. Some were complaining: *"I didn't like that it was literally all team work, some individual work would have been nice"*. While others expressed the opposite opinion: *"I enjoy group work, I think it's a good idea, in a good way to hear other people's ideas and other people's opinions"*.

To mitigate this issue, further iterations of the Ubicomp module were designed so that a part of the coursework required working in a team (the first part of video creation and initial discussions of the big questions), whereas the rest of the work (preparation of the final videos, and writing a blog post to answer the posed big questions) was individual. That allowed the instructors to keep the collaborative spirit in the class even though the course assessment was based on the students' individual submissions.

When asked to what degree the group work had contributed to learning at the SFC in Uppsala, the majority of students highlighted that they believed the group work had contributed significantly, none of the respondents said it was insignificant. These findings, of course, have limited generalisation potential due to small sample sizes; nevertheless, they indicate further implication for instructors who might consider to explain to students the value of group and individual work as part of learning and skills outcomes of the course.

c) Students as communicators

An important part of collaboration and peer-learning is the ability to function as a communicator. According to Hobbs (2010), through creation of meaningful and accurate messages "for real audiences, using digital tools, images, language, sound and interactivity", students will not only develop their knowledge and skills but also discover the power of being effective communicators. This is particularly interesting in the context of learning; recall, for instance, the common claim "I didn't learn the stuff until I had to teach it!". As seen in the interviews of Ubicomp instructors, preparation of videos forces students to rethink the subject and understand it deeper. Effective communication is hence an indicator of effective learning.

When analysing how students communicated their knowledge to other students through the creation of artefacts, and how they viewed sharing of the artefacts with students in future course iterations, I found that this aspect was much appreciated by many students. Here is an illustrative quote from a student of the "Complex IT systems in large organizations" course: *"The course gives the chance to develop skills that would otherwise only be possible on self-help basis such as communication, leadership skills, etc."*.

Similarly, 63% (n=12) of survey respondents from Ubicomp 2017/2018 said that they thought that the types of coursework that required multimedia creation (e.g. a video clip or a creative text) were helpful to develop the skills that would be useful in their future careers.

In addition, the study of media literacy skills acquisition (Chapter 6, Section 6.1) shows how students who create multimedia materials develop skills which help them to become successful communicators. One of the students from Ubicomp 2015/2016 commented: *"I learned how to create a concise and informational video, which can be used to demonstrate my knowledge in a more 'interesting' way."*

The ability to communicate effectively is one of the widely recognised essential life-long learning skills (Partnership for 21st Century Learning, 2015) and therefore needs to be considered for inclusion into any subject teaching. This research and the proposed SFC approach can help the instructors to implement it.

d) Students as learners

The ultimate goal of the Self-Flipped Classroom, as of any pedagogy in general, is that students learn. The above roles are strongly influential in how well the learning takes place. One should note that not all students appreciate active learning approaches and learning from peers as they are often not used to this in their learning environment. When asked to comment on the statement "We have been given the opportunity to be active during the course" in a survey after the SFC at Uppsala University, one of the students said: *"To a too high degree - there's barely any teaching at all."*

In contrast, other students did see the value in the new approach. For example, when students from Ubicomp 2017/2018 were asked to agree or disagree with the statement "I think this coursework (video and blog post creation) has helped me to learn the course material better", 35.3% (n=6) agreed with it and 52.9% (n=9) agreed strongly; only 11.8% (n=2) disagreed. One of the students also commented: *"It did force me to gain an understanding of the task thoroughly so that I knew I had the knowledge to explain precisely what to do."*

When the same students were asked about their attitude towards using materials and resources previously produced by other students, 63% (n=12) of respondents preferred to use those materials to learn the course content and 73.6% (n=14) preferred to learn how to create similar course work. One student said: *"Having these resources available was useful to see how to and how not to do things and to clarify the topic area".*

Table 7:1 presents a summary of knowledge and skills that students can acquire and develop through the two phases of SFC learning. Not every knowledge and skill category in this table was directly measured during this research, however, I saw many indications for their presence. Below I elaborate on some of the entries in the table using observations from the case studies.

Table 7:1. Knowledge/skills that can be acquired and developed in the two phases of SFC learning

	Phase 1: Creation	**Phase 2: Reuse**
Subject knowledge and skills	- Reflecting, deeper understanding (being able to teach) - Try-outs (making sure it works on the video) - Practical demonstration of the learned content - Design skills	- Other perspectives on the subject content (peer-learning) - Critical analysis of the content in peer-produced materials
Transferable knowledge and skills	- Team work/collaboration - Communication - Creativity - Self-confidence - Media literacy - Video-making - New perspective on multimedia creation - Copyright and fair use principles	- Critical thinking - Critical analysis - Reflection

In Case Study B, I observed the lack of criticality on student-produced videos: the students did not see much of a problem with low quality videos. One explanation for the lack of criticality is poor media literacy skills of the students. The process of video creation they went through did not help them to develop the skills of media literacy to the same level as in Case Study A. In particular, the process was less collaborative, and the students did not go through the phase of analysis and evaluation of a large collection of pre-production video materials before creating the final results. The fact that different teams could not see what other teams were working on, and how, reduced the impact of peer-learning. When a tool like Bootlegger is not available, it is possible to address this issue by introducing a formative assessment element, e.g. peer assessment, so that the students could evaluate each other and learn from it.

The aspect of evaluation and critical analysis can be discussed from multiple angles:

- Trust and overtrust: there are factors that can contribute to the non-critical attitude to the student-produced materials, such as the assumed "instructor's quality control" and an idealised, error-free "transfer" of someone else's truth (e.g. truth from an interviewed expert). The ability to recognise trustworthy information is a part of the media literacy skillset. In the media literacy study, I found a tendency of students preferring materials created by their peers with a reputation of being excellent students (who also received the highest marks at the end of the course). This suggests that students-consumers demonstrated their trust in the "internal quality control" of "top" students-producers. This suggests that the level of trust in the observed case studies was influenced by the familiarity of students-consumers with the authors of the artefacts. Thus, when students-consumers knew the producers personaly they could make certain assumptions about their knowledge, skills, and, subsequently, the credibility of the produced materials (e.g. Phase I of Case Study A and Case Study B). On the other hand, when students used materials created by a different cohort they only 'relied' on the instructor's quality control (Phase II of Case Study A).
- There was an element of explicit evaluation of student-produced materials. In Case Study A, the students could 'star' best pre-production materials. In Case Study B, the student commented that some of the interview videos were "not to the point" or less interesting than they would have preferred. The students particularly satisfied with their own creations were actively (but not openly) comparing the other videos to their own.
- Moreover, in the collaborative approach to video production in Case Study A, one of the most important steps for the students was to critically evaluate pre-production materials (their own and produced by their peers) in order to synthesise their final video tutorials. Students had to learn how an instructional video can be put together and what was required for it. Through this video creation, students trained their ability to be critical about media, as explained by the following quote from one of the students:

> *"When we actually did that first video, like maybe a couple of weeks before the deadline, we kind of realised that there is all this content that we needed that we haven't actually been recording for all of the weeks, so in the end we had to go back and basically just record everything from scratch again."*

In the end, the students did demonstrate their ability to be critical and efficient when evaluating the pre-production video clips and putting them together in a meaningful way for the final video tutorial. I argue that by doing this, the students in Case Study A leaned better critical analysis skills compared to the students in Case Study B.

Similarly to the results of Engin's study (Engin, 2014), audience awareness and self-evaluation of the students producing video tutorials also helped to improve their subject learning. Some of them reported: *"When I made the tutorial, I had to make sure everything is working as it should. Otherwise, when writing a report, I might have missed a step or something…"* and *"It did force me to gain an understanding of the task thoroughly so that I knew I had the knowledge to explain precisely what to do."*

e) Student's reflection

Asking students to do coursework serves two purposes. Firstly, it lets students demonstrate to the instructor the acquired learning outcomes of the course. Secondly, it makes the students reflect on their learning themselves. The latter is more about the *process* of preparing the final coursework rather than about its actual content (much like writing a PhD thesis is not only about the thesis itself but about the researcher's development that occurs in the process).

Building on the definitions articulated by Schön (1983) in his work on reflective practice, I distinguish two types of learners' reflection in an SFC course, as shown in Figure 7:2. When creating an artefact, SFC learners engage in *reflection-**in**-action*, which includes reflection on the subject (i.e. that needs to be mastered in order to create a good artefact and thus to demonstrate acquired learning outcomes) and reflection on the process of creation itself (i.e. mastering the skills needed in the process of creation).

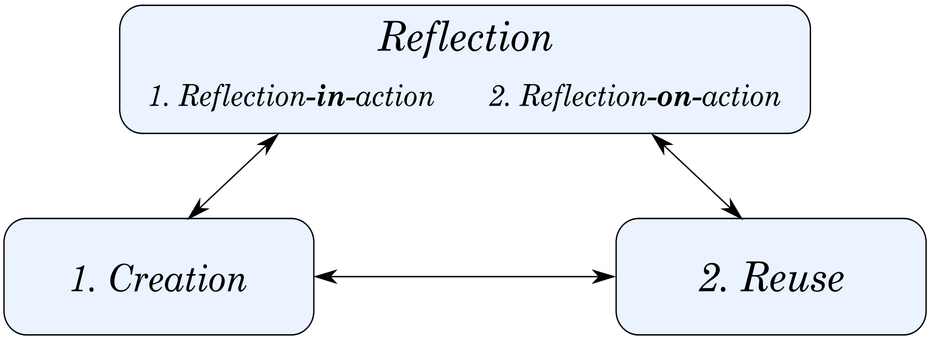

Figure 7:2. Self-Flipped Classroom learning cycle

When reusing an artefact created by someone else, SFC learners engage in *reflection-**on**-action*, which includes reflection on the delivered subject knowledge, the method of delivery, the creator's personal perspective, as well as reflection on the style and tools used to create the artefact. Unlike in Schön's work, where reflection-on-action occurred when reflecting on one's own past actions, in the SFC context, reflection-on-action occurs when reflecting on somebody else's past actions. As observed in the case studies on Enclosed and Distributed variants of the SFC, reflection-on-action was triggered more effectively in the students who had previously created SFC artefacts and thus initially engaged in reflection-in-action.

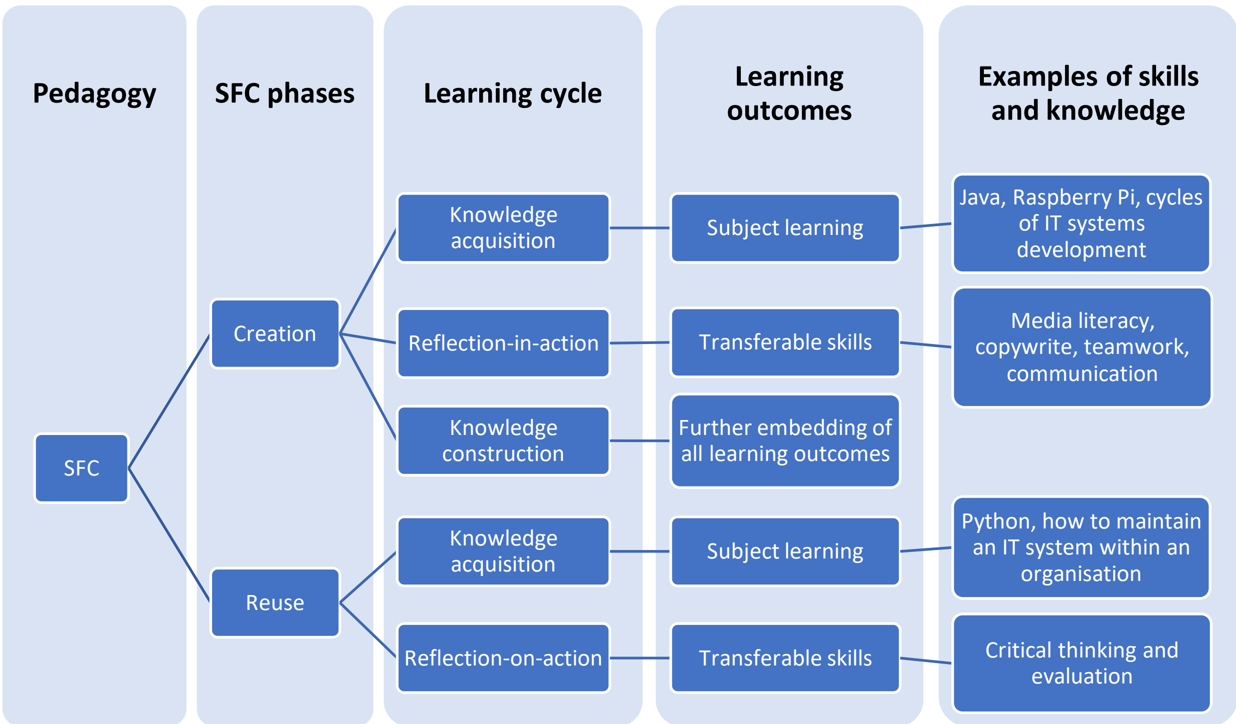

Figure 7:3. Skills and knowledge development within the SFC approach as a starting point for a framework of educational prosumerism

Figure 7:3 illustrates the Self-Flipped Classroom learning cycle in more detail, incorporating the two types of reflection and giving examples of skills and knowledge students developed in the presented case studies. This illustration makes a step towards development of an *educational prosumerism framework.*

7.1.2 Impact on Instructors

This section provides a brief summary of the SFC impact on instructors, as found in Case Studies A and B; a more detailed discussion can be found in Chapters 4 and 5, respectively.

In both case studies, the instructing teams faced a number of SFC-related challenges but in the end, there was a consensus that these challenges can be overcome, and that the extra effort invested in the initial iterations of the SFC-based courses will eventually pay off thanks to the opportunities that the SFC offers.

The challenges are listed below:

- **Curriculum and assessment design.** As any new methodology, SFC requires the instructors to invest greater effort into planning, preparing and running the course. Some of the challenges are similar to those when running Flipped Classroom based courses, for example, the need to motivate the students to study teaching materials before the class. There are also challenges specific to SFC, for example, assessment needs to be designed with the student artefact creation in mind.
- **Novelty (for students).** SFC is new not only for the instructors, but for the students too. In the conducted case studies, some students who were previously unfamiliar with the ideas of Flipped Classroom, active learning, or artefact creation, required additional motivation and explanations to accept and internalise these educational ideas, which should be taken into account when planning the introductory part of the course.
- **Quality control.** It can be challenging to ensure the high quality of teaching materials produced by students, especially in the context of the Enclosed SFC, where the time between creation and reuse of materials is short. It is worth mentioning, however, that students are generally less critical towards teaching materials produced by their peers, and the quality of student-produced materials was rarely mentioned by the students as an issue that hindered their learning.
- **Overtrusting content.** Students tend to rely too much on instructor's "quality control" with respect to the content of the student-produced materials but, as mentioned above, such control may be challenging. By steering students towards critical analysis of the

materials, it is possible to mitigate this issue, and at the same time improve their media literacy and critical analysis skills.

- **Scaffolding of student artefact creation.** The lack of standard and well-tested tools for collaborative video creation, editing, submission and playback poses a technology challenge, as well as a research opportunity. In Case Study A, we used Bootlegger, which is a very good fit in theory, but had a few issues in practice, which led to negative feedback from many students. In Case Study B, the students did not use any SFC-specific technological support. As a result, there were fewer complaints on technology but some aspects of collaboration and peer-learning were lost.
- **'Love it or hate it' course feedback.** In both case studies, the student course feedback was polarised. This relates to the above novelty and technology challenges: new pedagogical approaches often put students outside of their comfort zone, which, coupled with issues of using new technology, can easily lead to frustration. It was encouraging, however, to also see that large parts of the observed student cohorts were positive about the SFC ideas.

On the bright side, instructors also saw many opportunities provided by the SFC. Some of them are listed below.

- **Library of teaching materials.** The instructors were excited about the opportunity of creating and maintaining a library of student-produced teaching materials, especially given that there were examples of excellent quality. In the Distributed SFC, the instructor who reused the materials created by students from a different cohort said that these materials saved him a lot of time that he would have otherwise needed to spend for running a workshop in a Flipped Classroom format.
- **Novelty (for students).** While I have already mentioned novelty in the above list of challenges, it is important to recognise that new style of learning may in fact be more appealing to many students. The 'love it' parts of the studied cohorts were highly positive about the idea of creating learning artefacts as part of their learning, and about learning from artefacts created by other students. This suggests that by spending more time on explaining the ideas behind the SFC, instructors can increase the relative size of the 'love it' part of the cohort.
- **Satisfying and engaging experience.** When running the case studies, particularly, Case Study B, it was interesting to discover that instructors found the SFC an engaging experience, because they were also learning, by watching and assessing the student-produced artefacts. For example, they had a chance to experience interactions with

industrial IT experts through the interview re-enactments produced by the students. The instructors were also satisfied in trying out this new approach, as they believed that it helped the students learn better despite the aforementioned challenges.

- **New technology for student artefact creation.** Instructors believed that by pursuing the SFC approach and learning more about the requirements for supporting technology, it would become possible to create innovative tools for collaborative content creation that would empower the students to create better artefacts, thus further improving their learning experience.

7.2 Similarities and Differences between the SFC Variants

In this section I discuss the most important themes, such as student learning, motivation and engagement, which were observed in Case Studies A and B dedicated to the two SFC variants.

RQ 5: *What are the similarities and differences of Enclosed and Distributed SFC?*

In both case studies, and hence in both variants of the SFC, students felt that the first phase of the approach (the *creation*) brought them a lot of value in terms of knowledge and skills acquisition, which is consistent with the theory of *constructionism* where learning occurs as a by-product of making (see Chapter 2).

The value of the second phase (the *reuse*) was harder to evaluate. The students successfully received the course content from student-produced videos and, furthermore, many students highlighted their preference for the video format of delivery compared to more traditional lectures and texts. Also, in the Enclosed Self-Flip (ESF) setting, students had personal connections with the authors of the videos (their classmates), which increased their engagement and active learning when watching the videos produced by their peers. This is a clear advantage of the ESF. In contrast, the students in the Distributed Self-Flip (DSF) setting did not recognise the authors of the videos, and considered them as “others”. There was therefore no personal connection, although it is worth emphasising that this did not undermine the trustworthiness of the videos because the students believed in the quality control done by the instructor.

Table 7:2. Similarities and differences of SFC variants

	Distributed Self-Flip		**Enclosed Self-Flip**	
	Positive	Negative	Positive	Negative
Creation		Not all students go through both SFC phases	All students go through both SFC phases	
Reuse	More quality control			Some materials may be imperfect
Motivation to watch student produced videos		No personal connection with the authors, so no additional stimulus to watch the videos	More motivation to watch peer-produced videos, a desire to see familiar faces	
Trust	Trust based on belief that the instructor endorsed the materials (overlooking technical issues)			Trust based on belief that the instructor endorsed the materials, personal connection to the authors (may lead to over-trust)
Quality control	Instructors are in full control of the selection of materials			Little control, no time to re-make unsatisfactory materials
Learning from peer-produced materials	Confidence boost: *"if another student did it, I can do the same"*		Additional thinking (compare and compete)	
Attitude to technical flaws		Students notice more technical flaws in the materials created by unknown authors, which may negatively impact motivation to learn from these materials	Students tend to be more forgiving when they see imperfections in teaching materials created by someone they know	

Table 7:2 summarises the key similarities and differences of two SFC variants. Most of the entries in the table are self-explanatory. The 'Quality control' row refers to the difference

between DSF and ESF in the artefact selection process. In DSF, the instructor can choose the best exemplars of the student artefacts and discard the ones that are not suitable as teaching materials for other students. In ESF, there may not be enough high-quality materials to select from artefacts and may not be enough time to remake them.

It is difficult, and unfair, to compare the course evaluation and student feedback across all case studies because, unlike the Ubicomp and Complex IT systems courses, Physical Computing workshops were not compulsory and were offered to students as an extracurricular activity. The motivation and expectation of students were therefore quite different in these settings.

7.3 Considerations for Assessment in SFC

Previous literature on the popularity of MOOCs and the Flipped Classroom demonstrates the growing appetite for video in delivering instructional content (Guo et al., 2014; Bishop & Verleger, 2013). As access to video-making technologies increases thanks to smartphones and video cameras becoming widely available, students not only readily consume video materials but are now increasingly able to produce them at a high standard.

Learning by making, grounded on constructionism theory, has been proven highly effective by many studies (Hoban et al., 2010; Papert, 1986; Kafai, 2006b). Thus, the introduction of video-making into tertiary curriculums is a natural step (Mcloughlin & Lee, 2008). While video as a means of instruction is no longer a novelty, indeed becoming commonplace, and many studies report its benefits (Day & Foley, 2006; Singh et al., 2016), video as a means of assessment is still relatively novel, not well-defined, and under-researched to date.

Subjects with discursive and multidisciplinary nature, such as HCI or less technical IT courses, can sometimes fit awkwardly within the Computer Science curriculum due to the need to include subjective criteria (e.g. creativity and aesthetics in design) into assessment of such subjects, which is uncommon in Computer Science dominated by objective measures, such as structured deliverables, labs and exams. Furthermore, it is critical that the assessment scales appropriately with the size of the class without compromising the validity of judgments on achieving the learning outcomes. It is therefore important to have well-designed marking criteria for creative assignments such as video tutorials.

Videos that students create as part of their learning in a course could take various forms: presentation of research results, demonstration of a developed software or hardware prototype, tutorial for acquired skills, etc. Such video artefacts can be used in publications and student portfolios, potentially becoming external resources for another institution, paving way for cross-institutional peer-learning.

In the presented case studies, student-produced artefacts were part of the assessed coursework. However, none of them individually contributed more than 40% towards the overall mark. Other parts of the assessed work included tasks such as quizzes, hackathons, blog post writing, and home exam. This allowed the students to demonstrate a variety of skills, and the students who felt less comfortable with creative tasks were not disadvantaged. Most importantly, the assessment of artefacts was tuned to the demonstration of the subject learning rather than high quality of the artefacts themselves.

The assessment criteria for video-based coursework were weighted towards the quality of the presented technical skills and understanding of required concepts for working with Raspberry Pi ("Ubicomp"), and the clear demonstration of understanding of the principles and rules for working in large IT organizations ("Complex IT systems in large organizations"). The videography characteristics, such as clarity of the image and sound, pace of the presented information, use of captions and graphics, were assessed only as a medium to deliver the technical information.

As for the text-based coursework, the focus of assessment was on fitting of the work to the purpose: construction of a persuasive argument to answer a question ("Ubicomp"), or creation of a useful resource to learn about stages of complex IT systems life cycle ("Complex IT systems in large organizations"). The marks were weighted towards relevance of the artefact to both the student who created it and to the students who would use it later. Another significant component of the mark was a good use of a wide range of media and other references (including academic literature).

In general, the instructors on both of the case studies were impressed with the quality of some of the created artefacts. Many students have demonstrated creativity and other non-technical skills such as acting, drawing, high quality video editing, creative writing, etc. Some students went extra mile by creating prototypes for their videos, which further indicates their engagement and improved motivation in the course.

The experience presented in the case studies highlighted the value of student-authored video as an opportunity for learning through making and as a conduit for demonstration (Papert, 1986). It is important to ensure that marks are attached to the correctness of the presented concepts and the quality of produced prototypes, rather than to the quality of the video itself. For instance, in Case Study A, the biggest mark component was given to accuracy in explaining the steps required to achieve a certain task working with Raspberry Pi, whereas the criteria for the video communication were solely concerned with the effective use of the video medium (e.g. shot framing, pace of storyline), rather than the quality of the production itself.

The distribution of marks in this way is an important consideration for instructors wishing to utilise video as an assessment tool, and this is the main recommendation of this research for curriculum design. Furthermore, marking criteria need to equally assess technical skills and subject knowledge, as well as creativity and aesthetics. To be less subjective in assessment, a way of quantifying creativity and other non-technical characteristics of the produced video artefacts is needed.

Undergraduate students may not necessarily know the principles of fair use and copyright, which suggests another recommendation for curriculum design: class time should be dedicated to showing good examples of videos and explaining basic fair use and copyrights concepts.

7.4 Implication for Design

Based on the analysis of student and instructor experiences in the DSF and ESF settings, this research contributes design recommendations to tools supporting collaborative creation and pedagogy for blended learning courses. These design recommendations have evolved from the challenges and opportunities outlined in Section 7.1.2.

7.4.1 Implication for Course Design

A number of recommendations on course design for instructors who wish to incorporate the Self-Flipped Classroom approach into their teaching could be drawn from the results of the presented case studies.

- Be explicit about the pedagogical underpinnings of the Self-Flipped Classroom and be prepared to answer questions related to this new way of teaching.
- Students might find it difficult to appreciate the learning experience provided through the Self-Flipped Classroom, and some students appreciate traditional lectures where they are passive listeners.
- Discuss the different roles taken by students in the Self-Flipped Classroom and what kind of learning these result in.

- Be prepared to scaffold student artefact creation. Students who have not been engaged in content creation before do not always easily understand what is expected from them.
- Be prepared to work more with the university administration in the Self-Flipped course setting than in a traditional course: you may need to convince them too that innovative methods like SFC are worth trying. University administration is rarely keen on 'love it or hate it' student feedback.
- Be prepared to spend time on designing meaningful in-class and on-line learning activities, especially those that support student collaborative learning though making. Also, it might take additional effort to explain the value of Flipped Classroom type of activities to the students and to support their active engagement.
- Be prepared technically. If the collaborative content creation is supported by any tools, it is very important that the tools are stable and can scale up. The majority of students always work close to the deadline, which means a lot more traffic is expected when the students will be finishing their assignments/project and if the tool is not coping with it well, there will be a lot of frustration and negative feedback.

For those instructors who do not feel that they can confidently innovate with their course delivery, one approach is to gradually incorporate the teaching strategies/techniques that are less "scary" and feel easier. This recommendation was outlined 30 years ago by Bonwell and Eison (1991). Thus, for example, Enclosed Self-Flip can be introduced in two or more stages. During the first stage, the instructor will only ask the students to create content, and the reuse phase will be based on other resources. In the next iteration of the course, the instructor will be able to reuse some of the materials previously produced by the students and mix them with the other recourses. However, as has been discussed before, this approach reduces personal connection between student-producers and student-consumers, and is less effective in triggering reflective practices during the reuse phase, therefore, it is highly desirable to eventually transition to the full SFC cycle.

7.4.2 Implication for Technology Design

There is a need for design of two systems (or one with the features of the two) to support the SFC teaching approach. Specifically, there is a need to:

- Facilitate collaborative content creation, including (i) planning, (ii) storing, sorting and sharing of pre-production materials, (iii) editing and streamlined attribution (the latter refers to the ability to detect content reuse and automatically acknowledge the authors of the original content).

- Facilitate management of Self-Flipped materials, including (i) collection from students-producers and ethical curation, (ii) ranking and categorisation, and (iii) selection for reuse and distribution to students-consumers.

I elaborate on these design goals in the sections below.

a) Design for collaborative content creation for learning

Planning. The final videos of many Ubicomp students suggest that the students used the template for their videos that the instructor put into the shooting brief. This is in accordance to previous studies (Bartindale et al., 2016) that show usefulness of such prompts for inexperienced video-makers. It is important to note, however, that following/using such templates needs to be optional for the students, as otherwise it will limit their creativity. In fact, some of the best examples in Ubicomp videos were only indirectly influenced by the templates: the content had the same structure but video had more context (scenario), prompts (personas, prototypes) and demonstrated creativity.

Storing and sorting of pre-production material. Management of video materials in the cloud was a key feature of Bootlegger and, when it worked, students used it and appreciated it. It was, however, questioned by some of the students, e.g. those who produced the most reused content. Bootlegger also included a basic support for ranking and categorisation, similar to the PeerWise system where learners rate and star other students' contributions, which has an element of gamification, promoting motivation and engagement, and an additional prompt for reflective learning, developing critical thinking skills.

Sharing of pre-production materials. Sharing of video clips that were shot to document students' work was a key collaborative element of this coursework. Being able to access the cloud storage of all produced clips was highly appreciated by the students. In the interviews, they commented how this was helpful for their inspiration. Students clearly recognised the value of seeing the work in progress from other students.

Attribution. Attribution of remixed/reused work of others was one of the main problems in the collaborative tasks in Ubicomp course. Bootlegger did not have a functionality to make it automatic (e.g. by adding a watermark with authors names, or generating a list of contributing authors). Furthermore, this was not particularly emphasised in the coursework brief. As a result, not all students felt it was necessary to credit their class-mates for the video contributions, and none of the students made any attribution for the text/ideas contribution in the discussion forum. The students explained that "it was allowed to reuse" by the coursework brief. I argue that these findings should be used as design recommendation for collaborative content creation tools to ensure fair use in creative work and to teach students rules and standards of fair collaboration. There is an opportunity for design of new technology for helping students learn fair use and attribution, and stimulate good attribution practices by, for instance, automating the search and crediting of peer contributions within used social media platforms.

Editing. Bootlegger approach to make editing as a build-it function was helpful for novice video makers and allowed them to create their final edits easier: there was no need to buy and install more advanced software, and the interface was intuitive (pick, drag and drop clips into an edit stripe). It is important to support this feature.

Additional functionality for video editing. Video created for delivery of content to students should have specific form and structure. This is not simply a recorded lecture but purposefully created content, tailored to "digital consumption" with features such as non-linear navigation, a short format and embedded interaction (e.g. quiz) to encourage viewer engagement. Such function, if available for students, can help them to think further about teaching content (leading to more reflection, and more dimensions of learning). For example, a task could be: make a video for other students and include a few multiple-choice questions in it.

I draw two main implications for design of tools for collaborative creation of learning artefacts. The first is the facilitation of peer-learning in the exchange of ideas and pre-production materials at all stages of the production, for example, via a shared cloud-based storage of all artefacts and encouragement to make use of this shared space. The second is the facilitation of search and attribution functions.

In Case Study A, students highly appreciated the possibility to see their peers' pre-production materials (they were inspired by seeing work of others, and after watching the clips in the cloud, they re-did their clips by replicating/building on some of their peers' ideas). Students from Case Study B, however, did not have such technological support, and specifically asked about such feature, saying that this would help them to improve their work and results. "I'll see the others and will try to make my video better", said one interview respondent.

Therefore, I see a strong argument for introduction of technology that helps to facilitate sharing of student artefacts during different stages of production. There are values in each stage: (i) brainstorming ,where different ideas and approaches are tried in the very beginning (e.g.

from what angle to shoot a particular object, how to introduce different steps of a tutorial, etc.); (ii) further exploration and testing of different approaches in the middle of the process, when the students are able to see if a taken approach is working or not (which format is better, comical or serious, with headshots or text overlay, etc.); and (iii) at the end of the process, where some sharing of ideas is still relevant (e.g. how to edit the final video), and students can also can use the final products to compare and evaluate the results.

b) Design for the SFC support

To address the need for a repository for student-produced materials, we can learn from such examples as PeerWise (Bates et al., 2011; Denny, 2013), where the system (which was built to support student-produced multiple-choice questions) allows students to rate and upvote the best examples (through peer review), thereby enhancing the process of peer-learning and reflective thinking while at the same time managing (filtrating, sorting) the repository itself.

The repository, or library, of SFC artefacts should ideally come with the following features.

- A course management tool, with support for artefact submission, assessment and feedback provision (both for text and video artefacts).
- Management of the artefacts, with a system of tagging for categorisation and search, and a way to group artefacts into playlists.
- Support for upload and download of large files, which is necessary for video artefacts.
- Initial ethical checks: automated verification (e.g. via face detection) of required ethical approvals, copyright agreement management.
- Authors' rights management, for example, possibility for students to revoke their agreement for their artefacts to be stored and/or reused.

7.5 Chapter Summary

This chapter discussed the main results presented in this thesis and drew implications for design of future SFC courses, as well as for their technological support. While the nature of case studies explored in this work was focused on the Human-Computer Interaction and less technical Computer Science courses, the presented results and implications should be transferable to the wider context of Computer Science and STEM education. The transferability of the findings is warranted by the fact that many theoretical underpinnings of the Self-Flipped Classroom pedagogical approach, which were discussed in the Literature Review (Chapter 2), were either directly developed for or later adapted to Computer Science education.

Chapter 8. Conclusions

This thesis presented an investigation of a new pedagogical approach, called Self-Flipped Classroom, built on a synergy of *Flipped Classroom* and *learning though making* educational principles. In particular, this research was focused on (i) grounding the new approach on existing educational theories and practices, (ii) exploring students' and instructors' attitudes to and experience of teaching and learning within the proposed approach, and (iii) examining the impact that the approach has on students and instructors.

In this chapter I summarise the main contributions and limitations of my research, list opportunities for future research endeavours, and reflect on the whole SFC journey.

8.1 Research Contributions

In Chapter 2, I discussed some of the fundamental learning and cognition theories as well as modern educational practices that have led to the development of the Self-Flipped Classroom concepts. The first contribution of the reseach is therefore theoretical. It was guided by **RQ 1**:

RQ 1: *How is the Self-Flipped Classroom pedagogical approach grounded in existing learning and instruction theories and pedagogies?*

To answer **RQ 1**, I developed a framework that integrates most important examples of constructivist learning, and demonstrates how the main principles of the SFC approach are grounded in those theories and pedagogies. See Figure 2:1. Theoretical underpinnings for Self-Flipped Classroom presented in Chapter 2, Section 2.1.1.

In Chapter 2 I also reviewed earlier empirical works that studied elements of SFC, specifically, creation and reuse of learner-generated content, which helped me to identify research gaps and formule further **RQ**s to guide investigation of SFC application in practice. These questions were investigated in two case studies presented in Chapters 4, 5, 6 and 7.

Chapters 4 and 5 described the qualitative fieldwork undertaken in Case Studies A and B, respectively, which investigated two variants of Self-Flip: Distributed Self-Flipped Classroom (Case Study A) and Enclosed Self-Flipped Classroom (Case Study B). These two chapters jointly addressed the following research questions:

RQ 2: *What are the students' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

> **RQ 2A:** *What is the student acceptability and experience of creating multi-media materials as a compulsory part of coursework?*
>
> **RQ 2B:** *What is the student acceptability and experience of learning from video materials created by other students?*

RQ 3: *What are the instructors' attitudes to and experiences of the Self-Flipped teaching and learning methods?*

> **RQ 3A:** *What opportunities and challenges do instructors face while implementing SFC into their teaching?*

The case study design allowed me to conduct in-depth investigations of the two variants of the SFC approach applied in real-life educational contexts, and also study collaborative content creation and media literacy skills development as part of the SFC. By studying these aspects, I was able to form a rich description of the SFC phenomena, which is what my research aim was.

In addition to defining and evaluating the new pedagogical model, this research was concerned with investigating ways to teach a range of transferable or so-called 21st century skills. While testing and evaluating Self-Flip, I therefore took an opportunity to explore a few collaborative learning techniques. Findings from those pieces of fieldwork helped me to answer **RQ 4**:

RQ 4: *What transferable skills and literacies does the Self-Flipped Classroom pedagogical approach help to develop?*

My reflection on the two presented case studies had further led me to answer the following research question, which formed the basis of the discussion in Chapter 7:

RQ 5: *What are the similarities and differences of Enclosed and Distributed SFC?*

In summary, the outcomes of this research are:

- The SFC approach provided a great opportunity to engage students in higher levels of learning: firstly, by engaging them in the reflection-in-action during artefact creation, and secondly, by engaging them in the reflection-on-action during learning from the peer-created artefacts. The second kind of reflection stimulated such cognitive processes as evaluation and critical thinking, which are part of Bloom's taxonomy and indicate higher-order thinking skills (Krathwohl, 2002). These were much more prominent in SFC than in normal FC.

- The SFC approach, when combined with the use of collaborative content creation techniques and peer learning, provides a good ground for the acquisition and further development of multiple life-long learning skills that are highly valuable in today's world.
- Introduction of the SFC approach creates a number of challenges for the instructors. However, in both of the case studies, the benefits of enhanced learning for students, as well as enjoyment and satisfaction of the achieved results, outweighed the initial effort.
- The most preferable variant of SFC is cyclic Distributed Self-Flip, where students go through both of the SFC phases: creation and reuse. This variant takes advantage of all of the learning opportunities mentioned above, and also mitigates some of the most prominent challenges for instructors, such as being in control of quality of student-produced teaching materials, and the initial workload.

8.2 Limitations

The samples in both case studies are not suitable for generalisation due to their sizes. However, I hope that the results of this research provide insights on innovative classroom practices, on the use of collaborative content creation tools, and on how education practitioners can implement an advanced approach to peer-learning, which helps them to create reusable Flipped Classroom materials in the process.

Evaluation of Bootlegger was hindered by the tool's instability at the time of the study. Hence, the students and the teaching team faced several difficulties during the process, such as mobile application bugs, connectivity issues and scalability problems due to the rapid uptake of video editing. These problems led to a mixed attitude of the students towards the tool, and therefore affected the overall appreciation of the tool's impact. However, use of the tool in this specific context for the first time generated plenty of helpful feedback for its further development.

One of the limitations of the data collected on attitudes and experiences of participants of this study is that it relied only on their self-report. Tools such as validated survey questionnaires, perhaps with a focus on phycological aspect of attitude and experiences, could bring an additional perspective and would allow to triangulate the thematic analysis results further. Moreover, the fact that the participation in the interviews was voluntary and the student participants were self-selected may have led to another limitation of the interview – self-selection bias (Lavrakas, 2008).

One of the most common challenges in educational research is evaluation of effectiveness. So, the objective/actual (in contrast to perceived) impact of the new pedagogical approach on student learning was infeasible to investigate in formal authentic setting (i.e., in a non-elective assessed university course, fully controlled experimental settings are infeasible), therefore this research is limited in contribution on the effectiveness of student content creation and reuse of this content. A controlled comparative study of the SFC versus other pedagogical approaches is thus highly desirable.

Furthermore, even though this research defined a new approach to teaching, it did not focus on design and evaluation of active learning activities, i.e. on how well the students are engaged in the Self-Flipped classes. Types and quality of active learning activities have potential to greatly contribute to learning processes, regardless of the learning through making element of the course. This was not a part of this research and could be a direction for future research.

Finally, in line with the agenda of qualitative research in general, and thematic analysis in particular, I acknowledge influence of my (as a lead researcher) personal views and perspectives as well as my ontological stance (as critical realist) on the data analysis (meaning that my research and interpretations will always be partial and subjective). Further studies and use of the methodologies like mixed method and quantitative research would provide more insights on the effectiveness of the SFC approach.

8.3 Future Research Directions

The work presented in this thesis opens many interesting directions for future exploration, particulary in the areas of *learning through collaborative making* and *educational prosumerism.* Below I list some of the future research directions.

- Having obtained promising results with HCI courses, it is interesting to apply SFC in non-HCI and non-CS contexts, for example, in art, mathematics, or physical education.
- Reflective learning deserves a more in-depth investigation. For example, it is interesting to find what cognitive processes students are going through when they are learning from peer-produced materials. Additionally, incorporation of peer feedback and peer assessment activities is expected to enhance SFC, and it would be interesting to confirm this.

- Cross-cultural learning is very important for HCI, as for many other disciplines. A future research can investigate how the SFC approach would work in different cultural and multicultural educational contexts. Exploring how different learning cultures can impact the SFC approach is also an intriguing research direction.
- It would also be interesting to investigate student learning using peer-produced materials from a psychological perspective, for example: whether personal connection to the author of teaching materials impacts learning; whether knowing that the material that one creates will be reused for teaching other (familiar or unfamiliar) students impacts quality of the created materials.
- The use of video as an assessment medium offers much promise for meaningful student engagement in design and prototype development. I see a great opportunity in future work for qualitative analysis of the video artefacts in order to evaluate their technical and artistic quality from various perspectives. Results of such analysis might help to develop quantifiable characteristics of creativity and visual and audio aesthetics, tuned specifically for multidisciplinary courses, such as HCI.
- More work is needed to further investigate why students choose not to credit their peers' contributions and on their understanding of fair use in different media types. I hypothesise that the student exposure to learning activities that require fair collaboration and ethical content creation with a due guidance from the instructors can help the students to become accustomed to fair reuse and attribution behaviour. Proving this research hypothesis is an opportunity for future research.
- Future work can include a repetition of the study with a larger student cohort to further validate current findings and to focus on evaluation of the *learning through making* multimedia artefacts for CS and other STEM subjects. Also, examination of the student artefacts in more detail, from different perspectives, e.g. a professional videographer and other learners, could be an interesting research project.

Finally, I'd like to conclude the list with a research direction motivated by the global situation in 2020, where for a long period of time, many organisations including universities needed to operate remotely. Can the Self-Flipped Classroom be successfully applied in the distance learning context? There is so much to investigate in terms of collaborative artefact creation by students in the situation where they cannot be physically present in the same room. Moreover, as has been shown in the case study dedicated to the Enclosed Self-Flip, personal connection between students of the same cohort plays an important role in student motivation and engagement with teaching materials. Therefore, there is a reason to believe that seeing other students' faces and otherwise learning from peer-produced materials would change the learning environment for distant students.

8.4 Conclusion

This thesis has explored educational approaches that focus on enhancing the Flipped Classroom model with the reuse of student-produced artefacts. A new pedagogical approach, called the Self-Flipped Classroom, has been proposed to address modern education challenges, such as the development of a broad range of life-long learning skills and facilitation of effective student-centred active learning. The research has focused on investigating perceived impact of the SFC on university level education by studying student and instructor attitudes to and experiences of the proposed approach. The use and evaluation of the SFC in two authentic learning contexts led to a number of implications for education, and HCI research and practice:

- The Self-Flipped Classroom approach gives an opportunity for instructors to improve their course delivery by engaging students in effective learning through making and meaningful peer-learning, while at the same time helping them alleviate some burden of creation Flipped Classroom materials themselves.
- Evaluation of experiences of Self-Flipped teaching and learning in two different educational contexts allowed to formulate a set of design recommendations for creation of a technological system to support effective use of Self-Flipped Classroom model.
- Results of Bootlegger evaluation and comparison of two case studies where one used a collaborative content creation tool and one did not, allowed to create a list of design considerations for further development of tools that support multidimensional *learning through collaborative making* and lead to student acquisition of several transferable skills.
- The results of this work contribute to the creation of an empirically driven framework relating the prosumerism behaviour and thinking processes to learning and skills outcomes in educational context. A continuation of this work has practical implications on instructors' knowledge and understanding of how students learn through making and using learner-generated instructional materials.

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Appendices

Table of Contents

Appendix A. Table of learner-generated material examples

Below is a list of different types of digital products that students can produce as part of their learning. The module instructor could reuse the best examples of these products as part of the Self-Flipped Classroom content to teach other students from the same or different cohort.

Type of student-generated material	Description	Examples	Resources and tools	References
Video tutorial	A 'How To' video which shows and explains steps necessary to solve a problem or to produce a particular result. This could be based on practical session exercises. Good for demonstration of practical skills learned during the module.	https://youtu.be/jC13S2rS_6U Learn HTML - Basic structure and how to link pages by LearnWebCode; https://youtu.be/JjiIoyj7D0g - Ubicomp 2015 students; https://youtu.be/_COmLT91amQ - Ubicomp 2016 students.	http://idratherbewriting.com/2012/09/27/how-to-create-video-tutorials-a-five-step-process/ https://www.techsmith.com/jing.html https://www.techsmith.com/camtasia.html https://www.movavi.com/support/how-to/how-to-create-videoguide.html	(Guo et al., 2014; Gravett & Gill, 2010; Engin, 2014)
Video presentation	An instructional video presents results of a research project done by students (in a group or individually). This should cover material which hasn't been presented by the instructor during the lectures or other teaching sessions.	https://www.youtube.com/watch?v=d85FgaFin2A - Green Energy Futures; https://www.khanacademy.org/video/introduction-to-work-and-energy - Khan Academy; https://youtu.be/Z	Video Project Evaluation Rubric: https://www2.uwstout.edu/content/profdev/rubrics/videorubric.html http://www.olejarz.com/arted/digitalvideo/interviewrubric.pdf	(Levick, 2014; Kearney & Schuck, 2006; Frydenberg, 2008)

	Good for covering broad range of topics within the module subject.	SgOWsOlUUw - SPG8025 students		
Multiple-choice question	A question from the course material (pre-class reading or video lectures) with several plausible answers. These questions should be submitted to the instructor before in-class sessions to demonstrate level of student preparedness for the class. Selected questions could be used during the class as a quiz or an interactive activity.		https://cft.vanderbilt.edu/guides-sub-pages/writing-good-multiple-choice-test-questions - how to write MCQ http://www.peerwise-community.org/wp-content/uploads/2013/07/Rubric-for-Rating-Questions.pdf - how to rate MCQ http://www.peerwise-community.org/resources/ - other resources	(Hardy et al., 2014; Bates et al., 2011; Casey et al., 2014; Fellenz, 2004; Bonwell & Eison, 1991; Gleason, 1986)
Problem to solve	A 'problem' is an issue that is investigated, discussed and analysed, which could take the form of an exercise, a puzzle, a scenario, a story, a dilemma or a case study.			(Wiggins et al., 2016; Barrett et al., 2011; Colliver, 2000; Norman & Schmidt, 2000; Prince, 2004)
Programming problem	An exercise to practice programming skills. This should address the material covered	Simple: Write a program that reads in two numbers and	How to assess programming:	

	on pre-class preparation or previous teaching sessions. The task includes writing a detailed problem to solve with the correct and optimal solution to it as well as a set of test cases to automatically check the solutions submitted by other students. Each proposed solution could be fully and objectively checked (number of test cases passed) without the instructor's involvement. Good for training programming skills and developing creative thinking. Good for large enrolment classes. (solving could be done individually or in small-group)	prints out their sum to the screen. Intermediate: Write a program that automatically converts English text to Morse code and vice versa. https://adriann.github.io/programming_problems.html	http://web.csulb.edu/colleges/coe/cecs/views/programs/undergrad/grade_prog.shtml http://lloydandlauren.com/wp-content/uploads/2010/05/Programming-Rubric.pdf https://samanthamorra.com/2010/07/19/scratch-rubric/	
Blog post	A short reflective essay about activities exercised during teaching sessions addressed to the student's peers. In this piece of work students will analyse practical	http://edu8213.org/feedback/	http://socialtriggers.com/perfect-blog-post/ http://chronicle.com/blogs/profhacker/a-rubric-for-evaluating-student-blogs/27196	(Costa & Kallick, 2008; Wheeler et al., 2008; Yew et al., 2007; Boulos et al., 2006; Churchill, 2009, 2011)

	applications of the material they learned before the class and how active learning sessions helped them to understand this material better.			
Editable wiki-pages	Wiki-pages enable learners to collaborate, share ideas, and curate content by editing the document together.	http://olc.onlinelearningconsortium.org/effective_practices/cjencyclopediacom-online-encyclopedia-criminal-justice	http://digitallyspeaking.pbworks.com/f/Handout_CharacteristicsQualityWikiPages.pdf	(Wheeler et al., 2008; New Media Consortium, 2007; Coursera-partner Community, 2013; Sener, 2007)
Podcast	A podcast is an audio recording which can be played on a computer or any portable player. Podcasts originally were only in audio format, however recently they more often include both audio and visual format (ex. Screencasts). For example, annotated class notes or screen- capture videos.	https://www.cmu.edu/teaching/technology/whitepapers/Podcasting_Jun07.pdf	What makes a good podcast: http://www.schrockguide.net/uploads/3/9/2/2/392267/evalpodcast.pdf Publishing - Podcasting Rubric: http://edorigami.wikispaces.com/file/view/Publishing+-podcasting+rubric.pdf	(Salmon & Edirisingha, 2008; Seery, 2012; McGarr, 2009; Frydenberg, 2008)
Vignette	Vignette is a short interactive summary of video lectures (screencasts/recaps)	https://prezi.com/im1qu0q0ghuv/copy-of-chemistry-	https://www.techsmith.com/camtasia.html - software to produce vignettes	(Read & Lancaster, 2012; Lancaster, n.d.,

	covering the critical concepts of the topic. Students supplement the summary with their commentary and examples. These are good to support student revision of the module or entire course content before the final exams.	vignettes/ - Universities of East Anglia and Southampton		2014, 2011)
Digital game	PC or mobile games that aims to introduce teaching content in an entertaining manner: in order to win the game the learner have to master certain skills or obtain information.	Scratch (MIT) https://scratch.mit.edu/starter_projects/ The Monkey Wrench (Prensky) http://www.games2train.com/site/html/tutor.html	https://gamesined.wikispaces.com/Game+Creation+Tools https://scratch.mit.edu http://www.sploder.com/free-game-creator.php http://www.digitaltrends.com/gaming/how-to-make-a-video-game/ http://marcprensky.com/digital-game-based-learning/	(Prensky, 2001; Harris et al., 2009; Kafai, 2006)
Animation	An animated video created either wholly digitally or by stop motion technique that physically manipulates an object in small increments between individually photographed frames, creating the illusion of movement when the		http://www.freemake.com/blog/5-best-sites-to-make-animated-video-trouble-free/ https://www.powtoon.com/edu-home/ https://youtu.be/lyB1Y9xkSec	(Stelzer et al., 2010; Hoban, Macdonald, & Ferry, 2009)

	series of frames is played as a fast sequence. The animations could be made to substitute video tutorials and presentations.		https://www.futurelearn.com/courses/filmmaking-animation-classroom https://goanimate4schools.com/public_index	
Slow Motion Animation	A stop-motion animation played in slow motion at 2 frames/second created to explain a science concept. The technique involves manipulation of models made out of plasticine or soft play dough as digital still photos are taken of each manual movement. In addition to plasticine a range of materials can be used (e.g. plastic models, wooden, paper or cardboard cut-outs) and a narration can be added to explain the concept.	http://www.slowmation.com	http://www.slowmation.com http://www.samanimation.com	(Hoban et al., 2010; Hoban, Macdonald, Ferry, et al., 2009; Hoban, Macdonald, & Ferry, 2009)

Appendix B. Case Study A, Phase I materials

B.1 Context

Ubicomp course outline

CSC3723: Ubiquitous Computing

Offered for Year:
Module Leader(s):

Teaching Assistant:

Owning School: **Computing**

Teaching Location: **Newcastle City Campus**

Semester 1

Credit Value: 10 ECTS Credits: 5.0

Aims

Provides a theoretical and practical understanding of advanced topics in ubiquitous computing. This module extends the basic notion of human-computer interaction and considers the principles, technologies, design and evaluation of computing when it is embedded into the everyday environment. The module will aim to provide students with an historical account of ubiquitous computing and the concepts and technologies that have driven development in this area, such as natural interaction, location-awareness and context-awareness. In addition, students will develop practical skills and experiences in building interactions with a number of cutting-edge ubicomp technologies and techniques, including interactive surfaces, tangibles and wearables.

Outline of Syllabus

- A history and ubiquitous computing
- Systems, interfaces and technologies for ubiquitous computing (including: wearable, tangible and embedded, interactive surfaces and tabletops, natural user interfaces)
- Context aware interaction
- Location in ubiquitous computing
- Privacy in ubiquitous computing
- Ethics of ubiquitous computing interfaces

Teaching Methods

Teaching Rationale and Relationship

This course will use blended learning to offer a complementary mix of directed learning around topics of interest alongside students' own independent learning based on resources provided within the course and beyond. Practical classes will offer student hands-on experience interacting with, and prototyping a range of ubiquitous computing technologies. To support students learning in relation to the philosophy and conceptual areas of ubiquitous computing small group teaching will be configured through games, debates and other active learning activities in scheduled weekly seminars. Students will be expected to prepare to take part in these face-to-face activities through actively participating in online elements of the course, which will include watching video-based short lectures on key topics, critically reading selected materials (both from formal publications, and selected web-based resources), and participating in online forums where "big questions" relating to the material are discussed. Students are expected to spend a significant amount of time each week preparing for face-to-face teaching, as well as reflecting on learning over the course of the semester.

Teaching Activities

Category	Activity	Number	Length	Student Hours	Comment
Guided Independent Study	Assessment preparation and completion	1	10:00	10:00	Development of project build
Guided Independent Study	Assessment preparation and completion	10	1:00	10:00	Completion of online quizzes.
Guided Independent Study	Assessment preparation and completion	3	2:20	7:00	Production of video tutorials
Scheduled Learning And Teaching Activities	Practical	9	2:00	18:00	Practicals offering hands-on experience with cutting edge ubiquitous computing technologies.
Guided Independent Study	Directed research and reading	10	2:00	20:00	Reading of weekly research papers & web resources, engagement with short video pod-casted lectures
Scheduled Learning And Teaching Activities	Small group teaching	10	2:00	20:00	Small group learning sessions, including mini-lectures, SOLE sessions, debates, games
Guided Independent Study	Reflective learning activity	10	1:30	15:00	Online discussions between students relating to "big questions" & reading (Reflective log 1)
Total				100:00	

The format of resits will be determined by the Board of Examiners

Other Assessment

Description	Semester	When Set	Percentage	Comment
Report	1	M	40	Blog post related to a new ubicomp concept or technology. (1000 words max.)
Portfolio	1	M	30	Three video tutorials describing practical work undertaken – max length 3 min each. (7 hours max.)
Prob solv exercises	1	M	10	10 online multiple choice quizzes which relate to online content - one per week (5 hours max.)
Reflective log	1	M	10	Participation with weekly online discussions forums (15 hours max.)
Prof skill assessmnt	1	M	10	Quality participation in face-to-face learning activities (debates, games, SOLEs) - (10 hours max.)

Assessment Methods

Assessment Rationale and Relationship

This course aims to encourage students to develop a conceptual and practical understanding of ubiquitous computing technologies and apply these understandings to the design and develop of a ubiquitous computing interaction using off-the-shelf prototype technologies. The hands-on and applied nature of much of the learning necessitates a coursework-based approach to evaluating students' learning (this hands-on approach is reflected in chosen teaching methods, with contact time being split between small group learning and hands-on practical classes throughout the semester). In addition, the course has been configured to require students to actively engage in constructivist learning experiences across the semester through a mixture of self-directed and directed learning experiences. Assessment relating to students' engagement in these learning processes aims to highlight the importance of participation. With multiple assessments spread across the semester the course aims to reduce assessment-burden, while ensuring that students are able to learn and build upon their assessed work over the semester.

Study abroad students may request to take their exam before the semester 1 exam period, in which case the length of the exam may differ from that shown in the MOF.

Reading Lists

CSC3723's Reading List (http://library.ncl.ac.uk/go/readinglists/CSC3723)

Student Name:

Total Score:

Instructional Video (worth 30% for all three)						
Serious Fail (0) No instructional video submitted	Fail (10.5) A video has been submitted, but lacks any specific details of how to complete the task using Pi. No attempt has been made to consider the learners needs and break a task into logical steps. Presentation of the video is poor, with badly chosen shots, or use of language.	Third (13.5) A video has been submitted, but it misses one or two crucial steps, or substantial detail of steps is missing. Presentation choices lack consideration for the learner. There is little variation in tone, graphics, or speed of video.	Lower Second (16.5) A reasonable attempt, with a video including most of the necessary steps. At times it is unclear how a step is achieved. Presentation and editorial choices are weak. Tone, speed and graphics / captions used in video are unengaging. There is little consideration of the learner's needs.	Upper Second (19.5) A good instructional video, including all the necessary steps, but some detail is lacking. Captions and graphics are used as appropriate. The presenter speaks relatively clearly using accessible language. Video is mostly interesting and engaging.	First (22.5) An excellent instructional video. Good detail provided for all the necessary steps. Excellent captions and graphics. The presenter speaks clearly, using accessible language at a legible pace. Good editing choices and variations in speed, tone and shot maintain interest and engagement in video.	Outstanding First (25.5) Same as for a first, plus instructional videos are exemplary. Student shows outstanding creativity in their approach to video creation.
Comments (write one comment to cover all three videos)						

Is GPS a good enough location sensor for self-driving cars? If not, what is?

If I had the chance to get in a self-driving car, that gained all of its location data solely from GPS, I'd probably have to say thanks, but *no thanks*. After all, it's well known that GPS can relay a location that's incorrect by several meters – not something I'd like to happen when the car is speeding down a motorway at 70mph.

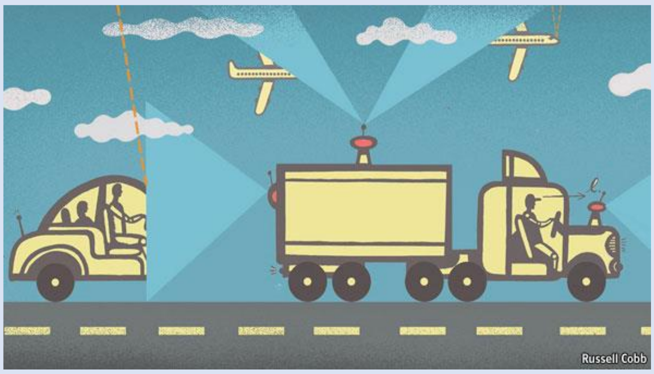
I've always been quite interested in location-based technologies, so it was fun to look in to all the different location sensors and systems available and what their potentials advantages and disadvantages they could bring to autonomous cars. It also helped to boil down what is required by a "location sensor":

1. Where the car is "**globally**". The accuracy is not a key focus of this location requirements, so it can be provided GPS.

2. Where the car is "**locally**". Here the car must determine its surroundings and plot the best path to avoid and react to obstacles in its vicinity. Accuracy is a very important factor for this definition of location, as it helps to prevent accidents and fatalities.

So what's the problem with GPS?

Not only is GPS prone to pipe us inaccurate data, but it can also be susceptible to a variety of problems. These range from natural interference like solar storms and tectonic plate shift (Reisinger, 2016), to man-made causes like signal reflection from faulty equipment and purposeful jamming of GPS signals.



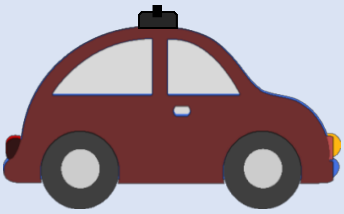
(Economist, 2011)

In 2009, the Federal Aviation Engineers in the USA noticed that Satellite Positioning receivers at Newark International were suffering daily breaks in reception.

When they investigated, they found it was because a truck driver was using an illegally installed GPS jammer, to prevent his employer from being able to track him during work hours. Thankfully no planes were affected – but imagine how this would affect a car on the road, that entirely relied on GPS for its location services.

So what can we use instead?

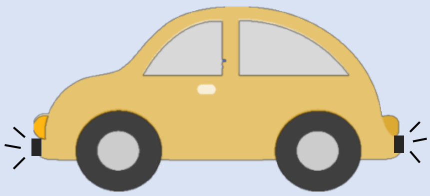
1 - Lidar



Also described as "a light-based equivalent of RADAR". Lidar is comprised of a laser range finder which creates a 3D image of its surrounding location by firing out laser beams and measuring how long they take to "bounce back". (LiDAR, 2010)

By measuring the returning signals, they can develop an idea of the potential hazards and road blocks for an impressive 200m! However, this also means that a vehicle with only Lidar installed can only determine its local location within the 200m, and isn't aware of anything outside of this range.

2 – Good Old-Fashioned Cameras



By using a sophisticated set of algorithms, cameras can be used to determine the surroundings of the autonomous car. These can be mounted in several locations on the car in order to build a better picture of its current location.

By allowing the car to "see" objects in its environment collisions with motorists and pedestrians can be better avoided. It can also be used to detect informatibetter road signs and traffic lights, allowing the car a better "contextual-awareness" of its surroundings. However, just like Lidar, with this technology the car is only ever aware of what the cameras can "see" and nothing more. (Google, 2009)

3 – Gyroscopes, Altimeters and Tachymeters

These ranges of gadgets and gizmos help to determine the very precise location of the car. Gyroscopes measure rotational motion, and provide measurements on the rotational and liner motion of the car. This can then help to calculate the current orientation, position and motion of the vehicles, and unlike GPS, cannot be jammed or disrupted as it is an internal unit. (Google, 2009)

Altimeters will help to measure the altitude of the car and Tachymeters will compute speed based on distance, or distance based on speed.

These sensors are not suitable by themselves, however when combined they can provide a better picture of a vehicles current "local" location.

4 – Service Maps

So, if the above examples still aren't quite resolving the issue of location. Then what about Service Maps?

Service Maps are pre-recorded routes that feature things like lane markers and traffic signs. It usually uses recorded visual and Lidar data to build up a route map which the car can then safely navigate.

A start-up version of this technology is contained in the video above. The "Civil Maps" software is touted as a "self-learning cognitive perception system that replicates human contextual awareness to allow machines to perceive, orient and respond to the physical world" (Maps, 2016). You can see in the video how signs and obstructions are perceived, identified and then the corresponding action is taken – if the traffic light is green then the car carries on, if the road is blocked then the car merges into an appropriate lane.

It is still in early stages, and would rely on a lot of recorded data in order to be functional across the globe, however it's an exciting new introduction to the world of location based technologies. However once again the car is only aware of its position in the local vicinity, and not aware of its true global location.

So is there an answer?

Tesla, Ford, Google, and now even Apple (BBC, 2016), have chosen to join the drive towards creating autonomous vehicles for the future – so there must be suitable technologies available in order to safely provide location information to the on-board computer that allows its passengers to be "hands off".

The trick is to not rely on *one* simple technology.

A single technology might fail, whereas four or five systems working concurrently would allow an autonomous vehicle to be aware of its global and local position. This redundancy in systems helps to build a complete data set, allowing the car to react to its environment and provide a safer experience than if it were to solely rely on GPS services.

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Discussion forum thread sample

Ubiquitous Computing

From Open Lab – Newcastle University

Is GPS a good enough location sensor for self-driving cars? If not, what is?

Forums › General Discussion › Is GPS a good enough location sensor for self-driving cars? If not, what is?

This topic contains 41 replies, has 42 voices, and was last updated by [redacted] 9 months, 4 weeks ago.

- Author

Posts | Favourite Subscribe

- 19th October 2016 at 4:21 pm Reply

[redacted] *Module leader*
Admin
Points: 67

Location is a hot topic in the field of Ubicomp. Of course, location awareness and tracking is of critical importance to the vision in self-driving cars, and so this week I'd like us investigate the kinds of technologies used to enable location awareness and tracking in self-driving cars, and if / where the current flaws might be in these systems.

I'd like you to do your own research to investigate this question. You'll need to think about what the scope of location means in the context of a driving car – is it simply knowing where the car is on a route, or are there other locational factors which need to be taken into account. (This reminds me of our discussion as to whether the weather is an element of locational information…) Discuss systems and technologies you are aware of, or come across through your research, that provide self-driving cars with an understanding of location, or may be used in

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You have collected a total of **105** points.

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the future. Feel free to share academic or online resources which have helped you to think about this question.

Like last week, those submitting a blog post (at the end of term) on this big question can take this opportunity to lead the discussion and share the research you have done so far.

- 19th October 2016 at 5:23 pm Reply

[redacted]
Participant
Points: 54

The UK's Transport Research Lab has these self-driving "cars" which are a trail system: https://www.youtube.com/watch?v=pj9-vL5JFqo

They use LIDAR sensors which are described as "a light based equivalent of RADAR" (https://www.engadget.com/2015/02/17/driverless-meridian-shuttle/) in order to help them navigate.

I think this shows self-driving cars need two kinds of location. They need general location sensing (i.e GPS) so they can add this to a map to figure out how to get to their destination. But they also need to sense their location and the location of things around them, otherwise it would not know how to cross a junction safely, but it would be able to figure out which exit from the junction to take.

- 19th October 2016 at 6:34 pm Reply

[redacted] *Author of correspondent blog post from the sample example*
Participant
Points: 122

I've always been quite interested in location-based technologies, so it was quite fun to look in to all the different location sensors and systems available and what their potentials advantages and disadvantages they could bring to autonomous cars.

If I had the chance to get in a self-driving car, that gained all of its location data solely from GPS, I'd probably have to say thanks, but no thanks. After all, it's well known that GPS can relay a location that's incorrect by several meters – not something I'd like to happen when the car is speeding down a motorway at 70mph.

Not only is GPS prone to pipe us incorrect data, but it can also be susceptible to jamming, visibility issues (tunnels), poor reception, tectonic plate shift, electromagnetic pulses, solar storms… and the list carries on.

It's a valuable service, but not reliable enough to be the only service. However, others services and technologies could be used to supplement GPS.

So what could be used?

1) European Geostationary Navigation Overlay Service (EGNOS) – a satellite based augmentation system that supports GPS by reporting on the reliability and accuracy of the location data.

2) Like Jsimpson mention, Lidar – A laser range finder, which helps locate the car in the local environment.

3) Altimeters, gyroscopes

4) Previously composed service maps

For a safer report on location, the data from these systems should be collated and used to more accurately report on the location of the car, in order to make autonomous cars reliable and safe.

An applied example of this idea could be found in the Google Car, that takes in a range of location data and collates it, in order to increase the precision with which a car can be located.

- 20th October 2016 at 12:35 pm Reply

[redacted]
Participant
Points: 71

GPS isn't a good enough location sensor as we all know that GPS isn't exactly accurate when there's obstacles in the way or extreme weather conditions like storms etc. So I really wouldn't give a self-driving car with just GPS as the location sensor a second glance

Google's self-driving cars use the LIDAR system, as mentioned above. Google uses a range of detection technologies like stereo cameras, lasers. sonar devices and radar. By using a laser it allows accuracy up to 100m! This article talks about how Google makes use of a range of technologies in order to give the most accurate information as don't forget you'll need more than just a location sensor, you can't rely on that to tell the car what obstacles are around it so it can work out how to avoid them

- 20th October 2016 at 12:52 pm Reply

[redacted]
Participant
Points: 73

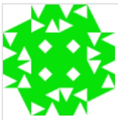
In my opinion GPS is not a good enough location sensor for self driving cars, at least not by it's self as it isn't precise enough to pin point exactly where on the road a car is which would be very dangerous if an autonomous car was to turn a corner even a small number of meters before it should. however I think that GPS probably will be used in self driving car in conjunction with other technologies this article mentions how for testing the google car the team working on it made detailed models of their testing track so the car new what kind of environment it would be driving in, in real life having a human team doing this would be impractical so the car would normally attempt to map it's surroundings in real time using all kinds of different sensors such as cameras and radars.

- 20th October 2016 at 3:27 pm Reply

[redacted]
Participant
Points: 60

GPS alone is not a good enough location sensor for self-driving cars, the location that current GPS has is not fast or accurate enough to be safe enough for a self driving car. If there was a slight delay or even if the cars location was off by a mere meter it could result in the deaths of people in the car, or in public and we know that GPS technology currently is only accurate to the nearest 5-10m. http://www.techradar.com/news/car-tech/the-tech-that-will-make-driverless-cars-go-1292426 Reading this article GPS will be useful but only in combination with things like Volvos, 360 degree radar and laser sensor so the car knows where it is.

- 20th October 2016 at 10:06 pm Reply



[redacted]
Participant
Points: 69

I don't believe GPS alone is good enough for self-driving cars. I believe self-driving cars need to have a sense of the environment around them along with the use of GPS. How can a self-driving car know how to change lane or overtake someone with just the use of GPS? I believe other sensors along with GPS such as rangefinders and also radars are needed. Taking into consideration the weather, GPS signals can be decreased in cloudy and rain which means that they may not work as fast as a sunny non cloud day. Taking into account that the GPS signals may not be received as fast or even lost, the car could take a corner too late and end up crashing if it believes it in a position which is actually isn't because of a delay in the signal.

> How do self-driving cars work?

B.2 Ethics

Information sheets

Student information sheet

As a student in the module CSC3723: Ubiquitous Computing, you are invited to be part of a University project about innovative approaches to teaching and learning science subjects in higher education.

What is the purpose of the research?

The aim of this research project is to evaluate the effectiveness of alternative ways of assessment (collaborative video tutorial production and blogpost writing) used in CSC3723 as well as students' experiences of learning during the course.

Who is conducting this research?

This research is being conducted by Anna Vasilchenko and supervised by Dr Madeline Balaam as part of Open Lab. Open Lab is an interdisciplinary research group part of the School of Computing Science at Newcastle University.

How specifically do I participate?

The research should have minimal impact on your learning experience on CSC3723. At the end of the semester the researcher will have access to the materials you create during the course (including: all clips created with Bootlegger, final video tutorials, forum discussions on the module website https://openlab.ncl.ac.uk/ubicomp/ and final blogposts). You will also receive a separate invitation to take part in a questionnaire and/or interview about your experience of the module. Other than that, you should go through the course as you usually do.

What will happen to the information you collect about me?

Only the people directly involved in this research will have access to the raw data we collect. The data will be stored securely on the protected University's filestore service. All the information will be anonymised and treated as confidential in that you will not be identified by your name or face. The anonymised data and resulting analysis may be used in academic and non-academic publications and conference presentations.

Are there any risks?

There is no risk in taking part in this study. The data collection will be managed to ensure it does not impact upon your learning experience and assessment. If you consider that the data collection is having an adverse effect upon your learning then please contact: Dr Madeline Balaam, madeline.balaam@ncl.ac.uk

What if I change my mind or have questions?

It's important that you know that at any time, during or after the course, you can ask questions, stop your participation, or withdraw completely from the research project.

After reading this information, if you would like to take part in the project, please complete the attached informed consent form.

If you have any questions, please don't hesitate to contact:

Anna Vasilchenko
a.vasilchenko@newcastle.ac.uk
School of Computing Science | Open Lab | Floor 4
Newcastle University | 89 Sandyford Road | Newcastle upon Tyne | NE1 8HW

Instructor information sheet

Evaluation of Ubicomp 2015 module

The aim of this study is to evaluate new forms of teaching and learning in higher education. In particular, we are assessing the efficiency and effectiveness of the new course format and tools used in CSC3723: Ubicomp. The focus of the interview you are asked to participate in is the teaching team experiences in preparation and running the module.

What will I have to do?

We would like to evaluate the experience of each member of the Ubicomp teaching team. So, we will talk to you about your involvement in the module preparation and running. You are asked to participate in an interview which will run for up to one hour.

What information will you collect about me?

The interviews will be audio recorded, so that the researcher can go back over your ideas later on. If we don't make the recordings it is difficult to remember exactly what people say.

What will happen to the information you collect about me?

Only the people directly involved in the study will have access to the information we collect, we will use a code instead of your name on all of the information we take for the study; this will help keep your information safe. We will store the recordings we make for the study and the information we collect in a password protected computer at Newcastle University. The anonymised recordings and information we collect may be used in academic talks and publications.

Are there any risks for me in taking part in the research?

We will be meeting in pre-arranged time that we agree on and is suitable for you and the researcher within the University. We only want to chat so you should be quite safe, and if you feel uncomfortable at any time you can ask for the interview to end.

Do I have to take part?

No. You do not have to take part in this study. Even if you agree to join in at the start, you can change your mind later. You do not need to give a reason for not joining in, or for leaving later.

After reading this information, if you would like to take part in the project, please complete the attached informed consent form.

If you have any questions, please don't hesitate to contact:

Anna Vasilchenko
a.vasilchenko@newcastle.ac.uk
School of Computing Science | Open Lab | Floor 4
Newcastle University | 89 Sandyford Road | Newcastle upon Tyne | NE1 8HW

Student consent form (artefact data)

I, the undersigned, give my consent for the project and confirm that *(please tick box as appropriate)*:

☐ I have read and understood the information about the project, as provided in the Information Sheet.

☐ I have been given the opportunity to ask questions about the project and my participation in it.

☐ I voluntarily agree to my participation.

☐ I understand I can withdraw my consent at any time without giving reasons and that I will not be penalised nor will I be questioned on why I have withdrawn.

☐ I understand that Open Lab researchers in the project team will have access to the information collected and that the researchers will follow the agreed procedures for the storage of the data as detailed on the Information Sheet.

☐ I agree that written academic and non-academic publications and conference presentations about the research project can include the **anonymised information** from **videos (clips & edits), forum discussions** and **blogposts** I create for the course. (This could be quotes, screenshots and/or video extracts. The faces in the videos will be made unidentifiable.).

☐ I would like to be offered the option of being named and credited in references to my video tutorials and/or blogpost if it is used by the researchers elsewhere than academic publications.

If you would like to be contacted about other research or university related use of your video tutorials and/or blogpost, please, provide ***your non-university e-mail address****. So that we can contact you even after you complete your studies in Newcastle University (please print):*

Participant:

__________________________ ________________ _______________

Name of Participant Signature Date

Researcher:

___*Anna Vasilchenko*_____ ________________ _______________

Name of Researcher Signature Date

Student consent form for a research interview

I, the undersigned, confirm that *(please tick box as appropriate)*:

☐ I have read and understood the information about the project, as provided in the Information Sheet.

☐ I have been given the opportunity to ask questions about the project and my participation in it.

☐ I voluntarily agree to my participation.

☐ I understand I can withdraw my participation for at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.

☐ I understand that other Open Lab researchers in the project team will have access to the all information collected and that the researchers will follow the agreed procedures for the storage of the data as detailed on the Information Sheet.

☐ I understand that I will be interviewed for the study and that this interview will be audio recorded.

☐ I understand that audio recording and transcription from the interview will be stored securely on the protected University's filestore service.

☐ I understand that anonymised direct and indirect quotes from my interview may be used in written academic and non-academic publications and conference presentations about the research project.

Participant:

__________________________ ________________ _______________

Name of Participant Signature Date

Researcher:

___*Anna Vasilchenko*_____ _________________ _______________

Name of Researcher Signature Date

Consent Form (instructor)

I agree to participate in the study **"Evaluation of Ubicomp 2015 module",** conducted by Anna Vasilchenko as part of the Open Lab team.

- I have read and understood the information sheet about taking part in the study, and the interviewer has answered any questions that I had, I have no further questions. ☐
- I understand that I will be interviewed for the study and that this interview will be audio recorded. ☐
- I understand that the data collected for this study will be stored securely in the School of Computing Science at Newcastle University. ☐
- I understand that the information collected for this study will be used only for research purposes, and that my name and personal information will not be used on any documents or in any presentations about the research. ☐
- I understand that anonymised direct quotes from my interview may be used in publications or presentations. ☐
- I understand that I can leave the study at any time without needing to say why. ☐

Participant:

__________________________ ________________ _______________

Name of Participant Signature Date

Researcher:

___*Anna Vasilchenko*_____ _________________ _______________

Name of Researcher Signature Date

B.3 Research Tools

Interview questions

Ubicomp student interview schedule

Part 1: *About the course*

- How was your experience in Ubicomp?
- Can you tell me something that you think worked really well in the course?
- Would you tell me three things that did not work well (you struggled with)
- How did you go through the preparations before class? How long did it take? When do you usually start? How much of the content did you view?
- How do you feel about group discussions and group activities in class?
- What would you want other modules to adopt from Ubicomp?
- What do think of the assessment in the course?
- What are your thoughts on the course work (participation, quizzes, videos, report), how did it compare to other courses?

Part 2: *Artefact creation*

Video creation

- Did you ever create a video tutorial before Ubicomp?
- Did you like the idea of creating a video as part of a Computer Science course?
- How do you feel about making videos rather than writing reports for practicals?
- Did you find it useful in order to help you learn the course material?
- What do you think of Bootlegger? Did you use it? To what extent?
- Did you watch other students clips in the cloud?
- If yes. What kind of clips did you like? Why?
- How did access to other students clips impact on how you made your own clips?
- Did you collaborate somehow else with your peers for the video creation? (comment about common features, like drawing, etc.)

Blog post creation

- Did you ever create a blog post before Ubicomp?
- Did you like the idea of creating a blog post as part of a Computer Science course?
- Did you find it useful in order to help you learn the course material?
- How did you use the discussion forum?
- How often did you read it and contribute to it?
- Did you curate the discussion on your chosen topic?
- Do you think the forum worked as a space to discuss and debate ideas with other students (or it was merely a collection of separate view points)?
- Did you find the forum useful?
- How did access to other students' forum contributions impact on your individual blog post writing?
- What do you think was the most useful (references, different perspectives, something else)?

Part 3: *Content reuse*

- Did you use clips created by other students in your edits? If yes, did you give them credits for it? (did you think about giving credits to the authors?)
- Did you use ideas articulated by other students in the forum in your blog post? If yes, did you reference them?
- How did (or would) you feel if other students used your clips and ideas for their work?
- What do you think is ethical and what is not in this context?
- What is your understanding of plagiarism and fair use?
- Do you think editing other students clips into a new edit is plagiarism?
- Do you think course marks given for this assignment were fair?

- Anything else you wish add to any of the discussed topics?

Ubicomp teaching team interview schedule

- Would you tell me about your experience of teaching for Ubicomp module in general? (opinion/attitude about flipped learning)
- Can you tell me about your other teaching experience and compare it to the Ubicomp? (how much efforts did you put into modules preparation?)
- How did you feel about making videos? (How comfortable were you with video making?)
- How much time did you spend to prepare a video part of the lecture? (both headshots and video scribe)
- If you were asked to do the same class next year, how much time do you think it will take to prepare?
- Was there anything particularly new that you had to learn in terms of teaching/preparations?
- Did you find anything surprising in preparation or running the class?
- What was the easiest things to do?
- What was the hardest things to do?
- Did you like your experience in general?
- Do you think the course was a success?
- What would you do differently next time?
- What in your opinion make a good activity for the in-class session? Any examples? Why? What is the key thing? Do you think students liked it? Why?
- What do you think students thought about you class (the seminar)?
- Did you feel you were a part of a team?
- Do you think you are able to run the similar course by yourself alone?

Survey questionnaires

Survey questions for "Media literacy" study

1. Did you ever create a video tutorial before Ubicomp 2015? a. Yes b. No c. Not sure
2. Did you like the idea of creating a video as part of a Computer Science course? a. Yes b. No c. Not sure
3. How did access to other people's (other teams') clips impact on how you made your own clips? *For example, did watching clips of other students inspire you to do anything differently when making your own clips, or were there any examples of clips which inspired you to make something similar? Please, explain your answer.*
4. If you used other people's clips in your final edits why did you do so? a. I didn't capture any clips myself b. Clips made by other teams were of better quality c. Other students captured some clips that I didn't and I needed them for my edits d. Other reason (please, specify)________
5. If you preferred to use clips made by yourself (or your team mate), why did you choose these over other people's? a. I didn't watch others' clips b. I watched others' clips and decided that my clips were of better quality c. I wanted my edits to be made by a single person (a pair), or be of a similar style d. I didn't like the idea of using others work for my course work e. I just wanted to use my clips, I felt ownership over them f. Other reason (please, specify)________
6. What was important for you when you were selecting clips for your final edits? *Please, name a few criteria you used, as well as others that you think are important. You can pick up more than one option as well as add your own to the list.* a. Visual quality (sharpness, lighting, stability/not shaky, etc.) b. Audio quality (clarity, volume level, etc.) c. Clip is precise d. Clip is long enough e. Clarity of explanation given by the narrator/right level of details f. The clip has something unique in it (new detail, charismatic presenter, best demonstration of the result, etc.) g. Other ______
7. Apart from the main learning outcomes of the module, was there anything else you learned from creating these video tutorials? 8. If yes, what?

Link to online version of the survey: https://ubicomp2015.typeform.com/to/QIx4WU

Learning by making for science and engineering students

Thank you for agreeing to take part in this survey!

Newcastle University strives to provide cutting edge education to its students. Instructors in the Schools of Computing and Engineering are working on improving their teaching methods. That is why you are invited to take part in this survey which aims at understanding your attitude towards a teaching method based on the approach of "learning by making".

Imagine that as part of your coursework you are asked to create some instructional materials for someone else. For example, a video tutorial on how to work with Raspberry Pi for a first-year undergraduate student. How would you feel about it?

Please fill this quick survey and let us know your thoughts (your answers will be anonymous).

If you have any questions please contact: Anna Vasilchenko (a.vasilchenko@newcastle.ac.uk).
* Required

Part 1: A little bit about yourself

1. 1. I currently study at my *

Mark only one oval.

- ◯ First year
- ◯ Second year
- ◯ Third year
- ◯ Placement year
- ◯ Other: ______________________

2. 2. My major is *

Mark only one oval.

- ◯ Computing Science
- ◯ Electrical and Electronic Engineering
- ◯ Chemical Engineering
- ◯ Civil Engineering
- ◯ Mechanical Engineering
- ◯ Marine Technology
- ◯ Surveying, Mapping and Geographical Information Systems (GIS)
- ◯ Other: ______________________

3. 3. I am *

Mark only one oval.

- ◯ Female
- ◯ Male
- ◯ Prefer not to say
- ◯ Other: ______________________

4. 4. I am ___ years old *

Mark only one oval.

- ◯ Younger than 18
- ◯ 18-19
- ◯ 20-21
- ◯ 22 and older

5. 5. I am originally from *

Mark only one oval.

- ( ) UK
- ( ) Other: ____________

6. 6. I think that I learn best by *
(you may choose more than one)

Check all that apply.

- [ ] Listening to lectures in class
- [ ] Reading textbooks, articles, etc.
- [ ] Watching instructional videos
- [ ] Listening to podcasts
- [ ] Doing practical exercises

Other: [ ] ____________

Part 2: Learning by making

7. 1. I would like the idea of creating learning materials for someone else as part of my own learning. *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	( )	( )	( )	( )	( )	Strongly agree

8. 2. I believe this kind of coursework would help me to learn the course material better. *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	( )	( )	( )	( )	( )	Strongly agree

9. 3. I wouldn't mind sharing the materials I create with *
1 = Strongly disagree; 5 = Strongly agree

Mark only one oval per row.

	1	2	3	4	5
students from my class (during the course)	( )	( )	( )	( )	( )
other students who will learn the same subject	( )	( )	( )	( )	( )

10. 4. Knowing that materials I create for a coursework will be used by other students would impact my learning during the course. *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	( )	( )	( )	( )	( )	Strongly agree

11. 5. I would like other students to find my materials useful for their learning. *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	( )	( )	( )	( )	( )	Strongly agree

12. 6. I believe that sometimes students may be able to explain parts of course subjects to th fellow students more clearly than the instructor. *

Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

13. 7. I like the idea of using some materials and resources that other students have previousl produced when learning... *

1 = Strongly disagree; 5 = Strongly agree

Mark only one oval per row.

	1	2	3	4	5
the course content	⬭	⬭	⬭	⬭	⬭
how to create a similar course work	⬭	⬭	⬭	⬭	⬭

14. 8. I have already produced some materials that other students might use for learning as part of a course(s) in my previous study. *

Mark only one oval.

⬭ Yes

⬭ No

⬭ I'm not sure

15. If yes, please, give an example

____

16. If you have any comments or thoughts, please, write them here.

____

Done! Thank you very much for your answers!

R programmes/codes

This appendix includes examples of R programs developed for Bootlegger data analysis.

P1. Rank authors by their productivity, i.e. the number of created video edits.

```
# Load data
edits = read.csv("d:/data/bootlegger/edits.csv")

# Filter out entries authored by the module leader
edits = subset(edits, edit_made_by != module_leader)

# Extract columns edit_created_by and edit_id, and drop repetitions
authors = unique(subset(edits, select = c("edit_created_by", "edit_id")))

# Group rows with the same author, computing the length of each group
# i.e. how many edits he/she created
result = aggregate(authors["edit_id"], by=authors["edit_created_by"], FUN=length)

# Give the resulting columns more meaningful names
names(result)[1] <- "author"
names(result)[2] <- "productivity"

# Sort by productivity
sorted = result[order(result[,"productivity"]),]

# Plot results
plot(sorted[,c("productivity")])

# Save results to a file
write.csv(result, file = "d:/data/bootlegger/author-productivity.csv")
```

P2. Rank authors by their influence, i.e. the number of students who reused their clips.

```
# Load data
edits = read.csv("d:/data/bootlegger/edits.csv")

# Filter out entries authored by the module leader
edits = subset(edits, edit_made_by != module_leader)

# Extract two columns: edit_created_by (user) and clip_created_by (author).
# Drop repetitions
user_author = unique(edits[,c("edit_created_by","clip_created_by")])

# Group rows with the same author, computing the length of each group
# i.e. how many users
result                =                aggregate(user_author["edit_created_by"],
by=user_author["clip_created_by"], FUN=length)

# Give the resulting columns more meaningful names
names(result)[1] <- "author"
names(result)[2] <- "users"

# Sort by increasing reuse
sorted = result[order(result[,"users"]),]

# Plot results
plot(sorted[,c("users")])

# Save results to a file
write.csv(result, file = "d:/data/bootlegger/influence-stats.csv")
```

P3. Compute the timeline of all clip creation events, and annotate each event with the clip's popularity.

```
# Load data
edits = read.csv("d:/data/bootlegger/edits.csv")

# Filter out entries authored by the module leader
edits = subset(edits, edit_made_by != module_leader)

# Parse times
edits$captured_at <- as.POSIXct(edits$captured_at, format="%d/%m/%Y %H:%M:%S")

# Extract two columns: clip_id and edit_created_by
user_clip = edits[,c("clip_id","edit_created_by")]

# Drop repeated rows (we don't want to count the same user of a clip twice)
uniq = unique(user_clip)

# Group rows with the same clip_id, computing the length of each group
popularity = aggregate(uniq["edit_created_by"], by=uniq["clip_id"], FUN=length)

# Compute a table with clip stars
clip_stars = subset(edits, select = c("clip_id", "stars"))
clip_stars = aggregate(clip_stars["stars"], by=clip_stars["clip_id"], FUN=max)

# Compute a table with clip creation times
clip_times = subset(edits, select = c("clip_id", "captured_at"))
clip_times = unique(clip_times[order(clip_times[,"captured_at"]),])

# Compute a table with clip event ids
clip_event_ids = subset(edits, select = c("clip_id", "event_id"))

# Merge popularity and clip_stars tables
result = merge(merge(popularity, clip_stars), merge(clip_times, clip_event_ids))

# Give the resulting column a more meaningful name
names(result)[2] <- "clip_popularity"

# Sort by decreasing popularity
sorted = result[order(-result[,"clip_popularity"]),]

# Plot clip popularity
plot(sorted[,c("clip_popularity")], col=sorted$event_id)

# Save result to a file
write.csv(sorted, file = "d:/data/bootlegger/clip-popularity-with-events.csv")
```

P4. Finding correlation (measured using Pearson coefficient) between the popularity of a clip (i.e. the number of times it was reused in different video edits) and the number of stars given to it by the students.

```
# Load data
edits = read.csv("d:/data/bootlegger/edits.csv")

# Filter out entries authored by the module leader
edits = subset(edits, edit_made_by != module_leader)

# Parse times
edits$captured_at <- as.POSIXct(edits$captured_at, format="%d/%m/%Y %H:%M:%S")

# Extract two columns: clip_id and edit_created_by
user_clip = edits[,c("clip_id","edit_created_by")]

# Drop repeated rows (we don't want to count the same user of a clip twice)
uniq = unique(user_clip)

# Group rows with the same clip_id, computing the length of each group
popularity = aggregate(uniq["edit_created_by"], by=uniq["clip_id"], FUN=length)

# Compute a table with clip stars
clip_stars = subset(edits, select = c("clip_id", "stars"))
clip_stars = aggregate(clip_stars["stars"], by=clip_stars["clip_id"], FUN=max)

# Compute a table with clip creation times
clip_times = subset(edits, select = c("clip_id", "captured_at"))
clip_times = unique(clip_times[order(clip_times[,"captured_at"]),])

# Merge popularity and clip_stars tables
result = merge(merge(popularity, clip_stars), clip_times)

# Give the resulting column a more meaningful name
names(result)[2] <- "clip_popularity"

# Sort by decreasing popularity
sorted = result[order(-result[,"clip_popularity"]),]

# Plot results
plot(sorted[,c("clip_popularity")])

# Save results to a file
write.csv(result, file = "d:/data/bootlegger/clip-popularity.csv")

# Compute Pearson coefficient for the correlation between
# clip popularity and the number of stars = 0.6119259 (p-value < 2.2e-16)
cor.test(result$clip_popularity, result$stars, method="pearson")
```

Appendix C. Case Study A, Phase II materials

C.1 Context

Physical Computing project fund application

Strategic project application form: Innovation Fund 2017/18

A. Contact information

A1 Project title Development of a Physical Computing HE Toolbox for Engineering and Science Students
A2 Project lead (name and academic unit/service) Fernando Russo Abegão, School of Engineering
A3 Project lead's email address fernando.russo-abegao@ncl.ac.uk
A4 Names and academic units/services of other staff/students on the project team **School of Engineering: Staff -** Chris O'Malley, Jon Goss, Matthew Dyson, Richard Law, Rosemary Norman, Sharon Joyce, **Students -** Harry Middleton, Peter Wrixon (UG) **School of Computing: Staff -** Marie Devlin, **Students -** Anna Vasilchenko (PGR), Megan Venn-Wycherley (PGR) **School of Sciences: Staff -** Helen Adamson, **Students -** Adam Rodgers (PGT)
A5 Name of finance administrator in your unit Lyndsey Jones
A6 Use this space for a statement of support from the appropriate Head of Unit (see 3.3), including their name The School of Engineering offers its strongest support for the proposed project aimed at the development of physical computing tools and their deployment in a range of cross-discipline activities involving UG, PGT and PGR students. The project team fittingly includes academics and students from three Schools within SAgE, which will facilitate the various multi-disciplinary activities to be deployed. The proposed project is based on constructionism and thus offers students an exciting opportunity to work in an environment in which they can engage and create new knowledge in a way that is different to current practice at Newcastle. Prof Graham Coates, Director of Excellent in Learning and Teaching, SoE, on behalf of Prof Phil Tayler, HoS, SoE.

B. Project information

B1 Abstract of your project (max. 100 words) Raspberry Pi microcomputers, microcontrollers and 3D printing have great potential to engage students and provide innovative teaching of computer programming under constructive pedagogy. This allows students to test algorithms by interacting with the physical world through moving parts and sensors. The aim of this project is to develop a HE Physical Computing L&T Toolbox for science and engineering. This will be achieved by cross-disciplinary collaboration between computer science and other science and engineering students. Activities will comprise development of learning and teaching materials, workshops, makers competition and STEM activities, supplemented by prototyping projects to showcase the potential of the technology.
B2 Student involvement **Please show <u>either</u>:** **• how you plan to work with a student intern to do the project** **• how you will ensure other student involvement appropriate to the project** **why it would be inappropriate to involve students in doing this project** This project will be carried out in collaboration with students at different levels: 1) Two Computing Science Education PhD students will work with computing science UG students who will produce flipped classroom-type artefacts. These will be used to train other science and engineering students and external students (e.g. through STEM activities) in physical computing tools; 2) A series of activities will be open to a pool of UG, PGT and PGR students across the SAgE faculty. These

will comprise the learning-by-doing-it activities described below (workshops, competitions, STEM) and activities to assess the learning impact and gather feedback on the Toolbox as described in B6;

3) Three final year UG/PGT students from Chemical Engineering and Environmental Sciences degrees will be looking at case studies to deploy physical computing tools activities in master research projects, involving laboratory, pilot-plant and field research projects. We will expand the portfolio of case studies by engaging further UG/PGT students in master projects during 2017/18-2018/19.

B3 Detail of proposed activity. Please include:

- **Nature of activity**
- **Methodological approach**
- **Relevance to existing practice**
- **Brief statement of how any ethical considerations will be addressed**

The aim of this project is to develop a higher-education toolbox for teaching and learning of physical computing geared towards engineering and science students, and to deploy a series of cross-discipline activities to spread the usage of these tools in the classroom, student projects and PGR activities.

The advent of inexpensive computers, such as BBC Microbit, Raspberry Pi, microprocessors (e.g. Arduino, MBed) and 3-D printers, enables students to explore computer coding strategies by using physical components connected to their devices. The tangible nature of this approach has the inherent strengths of constructivist education (HEA, 2017) (Biggs and Tang, 2011). This allows students to internalise their skills and deep learning experiences by putting to test their creative and practical skills when exploring the computer programming functionalities, in particular by experiencing the physical effect of algorithms in physical components, such as when moving a robot, probing a sensor, or activating a display. Additionally, this approach can create opportunities to explore and interact with the surrounding world in monitoring and control of experiences, or when developing activities with the intent of building prototypes.

The activities of this project will follow the idea of *learning through making* and are grounded on the learning theory of *constructionism* (Papert & Harel, 1991). Constructionism advocates that the best learning happens when the learner produce physical constructions (=artefacts) that others can see and critique. According to Papert, learners engage in a conversation with their own or other people's physical constructions, and these conversations encourage self-directed learning, and as the result enable the construction of new knowledge (Ackermann, 2001).

Most of the physical computing devices mentioned above were developed with an educational intent (e.g. Microbit, RaspberryPi), or with the intent of enabling access to the "back room" working of computers, electronics and electronic components (e.g. Arduino), which became more complex over time and caused people to distance and lose interest in the mechanisms of operation (RAE, 2017). While the use of RaspberryPi microcomputers and Arduino/MBed microcontrollers is solidly established in the fields of computing and electrical & electronics engineering, the simplicity of operation and low cost means these have an enormous potential for teaching and learning in other fields of engineering and science.

Under our current practice with often theoretical and academic teaching, many of our students (e.g. in Chemical and Electrical Engineering degrees) are perceived as failing to engage with coding because they find it too hard. For example, students have often feed backed through staff-student committees or through written answers on Ombea (a response audience system), that they did not think there were enough activities on learning how to use computer programming to solve maths and design problems in non-computing modules, but they would fear the assessment and would prefer non-assessed learning activities.

Assessment plays a key role in students learning, and without that motivation, engagement often drops. To overcome that, this project will encourage students to engage in interesting problem solving exercises using cross-disciplinary project collaboration between computer science/electrical engineering students and other sciences/engineering students, workshops, drop-in activities, competition-based challenges and community engagement STEM activities. This will allow them to explore and succeed in a low-risk high-motivation environment, using a constructive approach, so they can develop their confidence and face assessed activities with greater success.

We propose to develop a Physical Computing Toolbox geared for Higher-Education Learning. We will follow a constructive learn-by-doing approach, and in parallel with the learning activities we will investigate the impact of these approaches in students learning. To do this we will implement a range of activities:

1) **Development of *learning materials*/student artefacts by Computing Sciences UGs** - this will

comprise a series of tutorial videos and other supporting materials that can later be used by other Science and Engineering students to learn how to use the Raspberry Pi and Microbit platforms and implement coding strategies.

2) **Workshop Series** - to SAgE students and staff (staff workshops to run aside). A series of topics are being considered, such as: introduction to Raspberry Pi, coding in Python, 3D printing and taking it further with sensors and modules. There is also potential to run C++, Arduino, and MatLab Interfacing workshops if the student's uptake is positive. The constructive approach will be used to structure and deliver the workshops around application topics in line with student's interests. For example, a workshop on "Learn How to Make Your Own Computer Games" would have implicit content on Python coding, and a workshop on "Make a Robot" would have implicit content on sensors and modules.

3) **Case studies:** A series of prototype design and construction case studies developed by UG/PGTstudents will be used to showcase application potential promoting student engagement and feedback for future implementation into the course curriculum. Current case studies include: 1) Real-time control and monitoring of a micro-brewery process using digital sensors and Raspberry Pi with data sharing on the web, 2) Development of a new lab experiment for Chemical Engineering Laboratory modules (CME2023/CME3040) using Raspberry Pis to acquire process data and determine sensor accuracy, 3) Aquatic vehicles control using Raspberry Pi, 4) Vegetation mapping in Conservation Trust bogs using aerial drone photography and Raspberry Pi visible/infrared cameras, and 5) Squirrel species identification and selective automated feeding.

4) **Makers Competitions:** A makers competition is planned to stimulate students ownership of learning. Two possible modes are envisaged: students can propose and execute a project, and application challenges can be set by research groups and invited industrialists who would like a physical computing device programmed and built and potential be able to sponsor prizes.

5) **STEM activities:** Raspberry Jam event open to the wider community. Raspberry Jam's are publicised worldwide, are free to attend and open to all ages, but particularly popular among the younger ages. Organisers and participants take part by sharing learning and showcasing their devices and code.

In addition to addressing the challenges in current computer programming teaching practice for science and engineering students in Newcastle, this project is relevant to create a pool of skills in multiple other areas: 1) the capability of the tools to interact with sensors and measurement probes can impact in the way we teach instrumentation and measurement science, 2) the use of 3D printing will open doors for UG/PGT students to include more prototyping in their projects and for PGR students to boost their research with creative design and innovation. The multidisciplinary nature of the activities will promote cross-cutting collaboration between students of different subjects. The development of workshop based activities will put Newcastle in a competitive position with other universities that publicise the use of these tools, such as Cambridge, Bristol, York, Strathclyde, Southampton, Glasgow, Queens-Belfast, and multiple renowned international institutions.

Post-project long-term sustainability will be ensured by: 1) online dissemination of the toolbox learning materials, 2) workshops for staff to learn how to use these tools, 3) embedding of learning activities in the curriculum whenever possible (e.g. Chemical Engineering lab modules), 4) planning of application for external funding for further development of activities, pedagogical research and national/international collaboration, 5) dissemination of project outcomes in the University L&T conference and potential external conferences, 6) publication of pedagogical research in educational journals.

Ethical Issues: Any research on activities and the results will be subjected to an ethical approval application (this should be straightforward, as the students' participation will be voluntary in both the project and the research). Electrical safety issues are not envisaged as all devices are designed for plug and play, but activities will be risk assessed and electrical safety training will be included as part of activities as determined by risk assessments. Soldering training and safety assessment will be provided when and if required for construction of specific devices.

References:
Biggs, Tang (2011) *Teaching for Quality and Learning at University*, Maidenhead - Open University Press.
HEA (2017) *Maker Culture*, https://www.heacademy.ac.uk/enhancement/starter-tools/maker-culture.
RAE (2017) *2017 Winner - Raspberry Pi*, http://www.raeng.org.uk/grants-and-prizes/prizes-and-medals/awards/the-macrobert-award/2017-finalist-raspberry-pi.
Seymour Papert and Idit Harel (1991) *Situating Constructionism. In Constructionism.* Ablex Publishing Corporation.

Edith Ackermann (2001) Piaget's Constructivism, Papert's Constructionism: What's the difference ? *Constructivism: Uses and Perspectives in Education*: 1–11.

B4 What outputs (resources, events, or other things) is your project expected to deliver?

-T&L toolbox to deploy physical computing in Science and Engineering HE based on student artefacts.
-Introduce students to additional coding languages, e.g. Python, to increase flexibility of skills.
-Series of workshops on RasPi, Physical Computing and 3D Printing for UG/PG taught and PGR students.
-Makers competition.
-Pack of case studies on implementation of physical computing methods in the curriculum.

B5 Give an indication of your project's timescale and milestones.

1. Development of workshop teaching materials S2 2017/18 - S1 2018/19
2. Run workshops & first makers competition from S1-S2 2018/19
3. Makers competition, STEM, research results in S2 2018/19
4. Evaluate project in S2 2018/19 - run a seminar on the project to inform our colleagues on the results. Discuss how the toolbox/general ideas from the project could be included in future UG and PG taught curriculum.

B6 How will you evaluate the impact of your project?

Feedback forms and focus discussion groups will be used to gather feedback from students involved in each of the learn-by-doing it activities. Questionnaires can be used before the workshops and competition period to establish student knowledge and motivation, and then again after to see if students claim any improvement. The information collected will allowed to better understanding how science and engineering students can be better engaged in learning coding through physical computing projects. Feedback academic staff, industry/employers on what we have done will also be valuable to assess good ways to embed some of these learning experiences in the curriculum.

C. Budget

C1 Using the template below, please provide a breakdown of costs, indicating the financial year you wish to receive the funds. The first row is completed as an example showing a request for a Graphic Designer's time.

Budget item	Calculations	Total		
		2016/17	2017/18	2018/19
Raspberry Pi 3 Kits	60 kits at £50 per kit.	£0	£3000	£0
Arduino Uno kits	10 kits at £30 per kit	£0	£300	£0
BBC Microbits	19 kits at £15 per kit	£0	£150	£0
Ultimaker 2 3D Printer	1 3D-printer for prototyping	£0	£2000	£0
HATs for multiple applications	30 HATS at an average of £25	£0	£800	£0
Sensors and electronic components	Variety of sensors and electronic components at multiples prices (£1-£20)	£0	£1750	£0
STEM Activities	Raspberry Jam	£0	£0	£500
Record transcriptions		£0	£0	£750
PGR fees for assistance with workshops		£0	£375	£375
	Total	£0	£8375	£1625

C2 Please give details of any matched funding you have secured for this project	The UG/PGT case studies costs are covered under the student projects funded by the schools, up to £500 /student.

Please email completed application forms to innovfund@ncl.ac.uk.

This document is available online: http://www.ncl.ac.uk/ltds/funding/teaching/
Contact for queries: innovfund@ncl.ac.uk

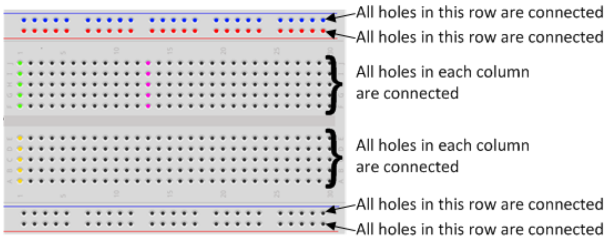
Workshop projects outlines

Project 1 – Intruder Alarm

GPIO Pins: GPIO stands for **General Purpose Input Output**. It is a way the Raspberry Pi can control and monitor the outside world when connected to electronic circuits. The Pi is able to control LEDs, turning them on or off, or motors, or many other things. It is also able to detect whether a switch has been pressed, or what the temperature is, or whether there is light.

Some pins have different functions. There are pins that provide power at 5 Volts and 3.3 Volts, ground pins (0 Volts), input/output pins and some pins that interface to external circuits in more complex ways. You are just going to use the basic GPIO, 3.3 V and Ground pins in these worksheets.

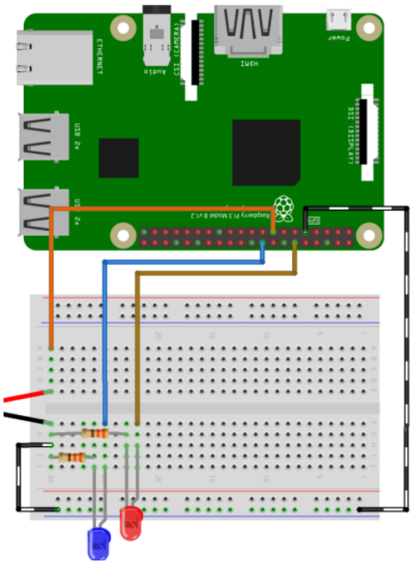
Breadboard: The breadboard is a way of connecting electronic components to each other without having to solder them together. They are often used to test a circuit design before creating a Printed Circuit Board (PCB).



LEDs: LED stands for Light Emitting Diode, and glows when electricity is passed through it. When you pick up the LED, you will notice that one leg is longer than the other is. The longer leg (known as the 'anode'), is always connected to the positive supply of the circuit. The shorter leg (known as the 'cathode') is connected to the negative side of the power supply, known as 'ground'.

LEDs will only work if power is supplied the correct way round (i.e. if the 'polarity' is correct). You will not break the LEDs if you connect them the wrong way round – they will just not light. If you find that they do not light in your circuit, it may be because they have been connected the wrong way round.

Resistors: Resistors are a way of limiting the amount of electricity going through a circuit; specifically, they limit the amount of 'current' that is allowed to flow. The measure of resistance is called the Ohm (Ω), and the larger the resistance, the more it limits the current. The value of a resistor is marked with coloured bands along the length of the resistor body.



In this project you will use 330Ω and 4.7kΩ resistors. In the LED circuit, you will be using the two 330Ω resistors. You can identify the 330Ω resistors by the colour bands along the body. The colour coding will depend on how many bands are on the resistors supplied:

- If there are four colour bands, they will be Orange, Orange, Brown, and then Gold.
- If there are five bands, then the colours will be Orange, Orange, Black, Black, Brown.

You have to use resistors to connect LEDs up to the GPIO pins of the Raspberry Pi. The Raspberry Pi can only supply a small current (about 60mA). The LEDs will want to draw more, and if allowed to they will burn out the Raspberry Pi. Therefore, putting the resistors in the circuit will ensure that only this small current will flow and the Pi will not be damaged.

It does not matter which way round you connect the resistors. Current flows in both ways through them.

Part 1: Building the circuit for the alarm lights:

While you could build the circuit with the Pi turned on, it is much safer to turn it off. Now take a look at the circuit diagram on the left.

Note: please ignore the orange line and the two red/black legs going out of the diagram on the left handside.

Think of the Pi's power pins as a battery. You will be using one of the Pi's 'ground' (GND) pins to act like the 'negative' end of a battery, with the 'positive' end of the battery provided by two GPIO pins, one for each of the two LEDs. You will be using the pins marked 18 and 24 for the Red LED and Blue LED respectively. When they are 'taken high', which means they output 3.3 V, the LEDs will light.

There are in fact two separate circuits in the diagram: 1) a resistor and the Red LED, and 2) a resister and the Blue LED.

Each circuit is going to share a common 'ground rail'. In other words, you will be connecting all of the circuits to the same 'ground' (0 volts) pin of the Raspberry Pi. You are going to use the top row of the breadboard. Remember that the holes on the two top and two bottom rows are all connected together? So, connect one of the Jumper wires from a 'ground' pin to the top row of the breadboard, as shown by the long black/white wire in the diagram. Here we are using the fifth pin in on the bottom row.

Then connect the jumper wire that has a pin on each end between the top row and the last column of the breadboard, as shown by the short black/white wire in the diagram. This will be the 'ground' (0v) for the two LEDs.

Push the LEDs legs into the breadboard, with the long leg on the left, as viewed in the circuit diagram.

Then connect the two 330Ω resistors between the 'ground' and the left leg of the LEDs; that is, the same column as the grey wire. You will need to bend the legs of each of the resistors to fit, but please make sure that the wires of each leg do not cross each other.

Lastly, using two Jumper wires, complete the circuit by connecting pins 18 and 24 to the right hand legs of the LEDs. These are shown here with the brown and blue respectively.

Coding!

Part 2 – Alarm lights

On the Pi, click on the Raspberry icon (like the start menu on Windows), go to “Programming” and select “Python IDLE 3”. From the file menu chose “New File”. A new window opens, go to the file menu and choose “Save As” to save your new Python file with .py extension – give it a cool name to go with your Burglar Alarm Project!

Type in the following code in the grey block:

```
# Import Python libraries

import RPi.GPIO as GPIO

import time



# Set the GPIO naming convention

GPIO.setmode(GPIO.BCM)

GPIO.setwarnings(False)



# Set the three GPIO pins for Output

GPIO.setup(18, GPIO.OUT)

GPIO.setup(24, GPIO.OUT)



print("Lights on")

GPIO.output(18, GPIO.HIGH)

GPIO.output(24, GPIO.HIGH)



# Pause for one second
time.sleep(1)
```

```
print("Lights off")
GPIO.output(18, GPIO.LOW)
GPIO.output(24, GPIO.LOW)

GPIO.cleanup()
```

Run your code by pressing F5.

So, what is happening in the code? Let's go through it a section at a time.

Note: Any lines starting with # are not executed with the code – the # characters tell the interpreter that that line is just a comment introduced to make the code more readable by humans and it should be ignored by the computer.

```
import RPi.GPIO as GPIO

import time
```

The first line tells the Python interpreter (the thing that runs the Python code) that it will be using a 'library' that will tell it how to work with the Raspberry Pi's GPIO pins. A 'library' gives a programming language extra commands that can be used to do something different that it previously did not know how to do. This is like adding a new channel to your TV so you can watch something different.

The 'time' library is used for time related commands.

```
GPIO.setmode(GPIO.BCM)
```

Each pin on the Pi has several different names, so you need to tell the program which naming convention is to be used.

```
GPIO.setwarnings(False)
```

This tells Python not to print GPIO warning messages to the screen.

```
GPIO.setup(18, GPIO.OUT)
```

```
GPIO.setup(24, GPIO.OUT)
```

These two lines are telling the Python interpreter that pins 18 and 24 are going to be used for outputting information, which means you are going to be able to turn the pins ‘on’ and ‘off’.

```
print("Lights on")
```

This line prints some information to the terminal.

```
GPIO.output(18, GPIO.HIGH)
GPIO.output(24, GPIO.HIGH)
```

These two lines turn the GPIO pins ‘on’. What this actually means is that these three pins are made to provide power of 3.3volts. This is enough to turn on the.

```
time.sleep(1)
```

Pauses the running of the code for one second.

```
print("Lights off")
```

This line prints some more information to the terminal.

```
GPIO.output(18, GPIO.LOW)
GPIO.output(24, GPIO.LOW)
```

To turn the LEDs off, you need to replace the GPIO.HIGH with GPIO.LOW. This will turn the pins off so that they no longer supply any voltage.

```
GPIO.cleanup()
```

The GPIO.cleanup() command at the end is necessary to reset the status of any GPIO pins when you exit the program. If you don’t use this, then the GPIO pins will remain at whatever state they were last set to.

Part 3 – Making your lights to flash

Now modify the code so it looks like this:

```
# Import Python libraries

import RPi.GPIO as GPIO

import time



# Set the GPIO naming convention

GPIO.setmode(GPIO.BCM)

GPIO.setwarnings(False)



# Set the three GPIO pins for Output

GPIO.setup(18, GPIO.OUT)

GPIO.setup(24, GPIO.OUT)



while True:

       print("Lights on")

       GPIO.output(18, GPIO.HIGH)

       GPIO.output(24, GPIO.HIGH)



       # Pause for one second
       time.sleep(1)

       print("Lights off")
       GPIO.output(18, GPIO.LOW)
       GPIO.output(24, GPIO.LOW)
```

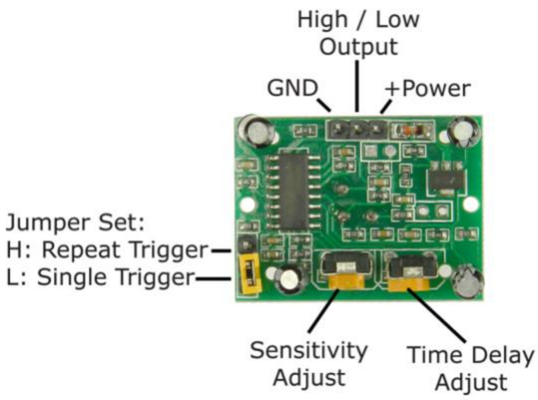
```
        # Pause for one second
        time.sleep(1)

GPIO.cleanup()
```

Run your code by pressing F5. To interrupt the code press Ctr+c.

What is happening? By nesting the instructions to swith the LEDs ON and OFF inside a “While” loop instruction, the instructions inside the loop keep repeating in sequence until the condition specified at the top of the loop is no longer valid. However, the condition specified in this case is “True”, which means it is always valid (i.e. it is always true) and the loop repeats for an infinite number of times or until we interrupt it by pressing Ctr+c.

Part 4 – Adding the movement sensor to the circuit



The main component of this circuit is itself another circuit board that has a PIR, or Passive Infrared sensor on it. There are three connectors on the bottom of the PIR, marked VCC (+Power), OUT (High/Low Output) and GND. A 5-volt power supply is applied to VCC pin, with GND pin going to ‘ground’. The OUT pin will ‘go high’ when movement is detected.

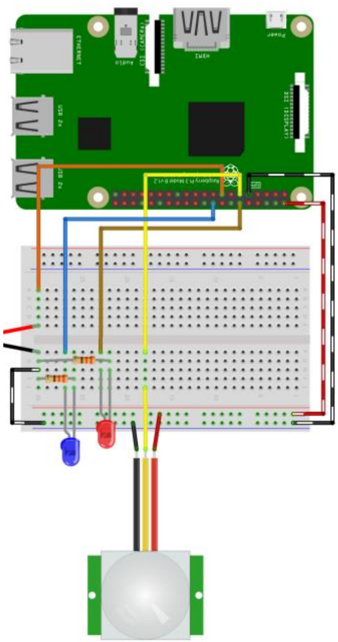
You will notice two ‘potentiometers’ on the bottom that are used for adjusting the sensitivity (marked Sx) and how long the sensor pin stays high when it senses motion (marked Tx). To make the PIR more sensitive, turn the Sx potentiometer clockwise with a small screwdriver. We have adjusted these for you so they work in the busy environment of the computer cluster – please do not change them! You may want to protect the sides so that it does not detect movement from other people in the room while testing.

The diagram on the left shows how to connect the PIR sensor.

Note: please ignore the orange line and the two red/black legs going out of the diagram on the left handside.

The PIR circuit is much simpler than the other circuits, mainly because the sensor contains a large amount of its own circuitry. Power is supplied from the 5v pin, and not the 3.3v that the other circuits use.

Use three jumper wires to connect the PIR pins to the breadboard. The power input pin is marked ‘VCC’, the negative marked with ‘GND‘, and the sensor pin with ‘OUT’ – check order of the pins by flipping the sensor upside down and comparing with the image at the top of this page. A second jumper wire connects pin 17 to the breadboard.



Part 5 – Coding the movement detection

Create a new file on the IDLE interface and save it with a new name. Type in the following code, paying careful attention to the indentation and nesting inside the loops and inside the if conditionals:

```
# Import Python header files
```

```
import RPi.GPIO as GPIO

import time


# Set the GPIO naming convention

GPIO.setmode(GPIO.BCM)

GPIO.setwarnings(False)


# Set a variable to hold the GPIO Pin identity

PinPIR = 17


print("PIR Module Test (CTRL-C to exit)")


# Set pin as input

GPIO.setup(PinPIR, GPIO.IN)


# Variables to hold the current and last states

Current_State  = 0

Previous_State = 0


try:
```

```
    print("Waiting for PIR to settle ...")


    # Loop until PIR output is 0

    while GPIO.input(PinPIR)==1:

        Current_State = 0

    print("Ready")


    # Loop until users quits with CTRL-C

    while True:

        # Read PIR state

        Current_State = GPIO.input(PinPIR)



        # If the PIR is triggered

        if Current_State==1 and Previous_State==0:

            print("Motion detected!")

            # Record previous state

            Previous_State=1


        # If the PIR has returned to ready state

        elif Current_State==0 and Previous_State==1:
```

```
            print("Ready")

            Previous_State=0



        # Wait for 10 milliseconds

        time.sleep(0.01)



except KeyboardInterrupt:

    print("Quit")



# Reset GPIO settings

GPIO.cleanup()
```

Run your code by pressing F5. To interrupt press Ctr+c.

So, what is happening in the code? Let's go through some of the new sections at a time.

```
PinPIR = 17
```

A variable, PinPIR, is being used to store the pin number of the PIR sensor pin. This allows you to change which pin is used in only one place in the code, and makes it easier to code by not having to remember the pin number, just the pin name you have given it.

```
try:
```

The main code is contained within a "try-except" construct. The code within the "try" will continue to be run until the "Keyboard Interrupt" keys are pressed. This is a special key combination that is defined within Python that will interrupt a program when pressed. For the Raspberry Pi, this is 'Ctrl + c', which is pressing the Ctrl key down and pressing the 'c' key. In normal circumstances, this would cause an error in the code and halt its exectution.

However, the ”try-except” construct allows the interpreter to handle “exceptions”, i.e. uncommon or erroneous circumstances, by letting them through and jumping to the next instruction. In this case, it will react to Ctr+c not by halting the code, by the just jumping out of the while loop, and executing the print and GPIO.cleanup() instructions which allow us to switch off the GPIO interface safety before stopping the program.

```
while GPIO.input(PinPIR)==1:
    Current_State
```

In the first while loop after the `try`, the code first waits until the PIR does not see any movement. The variable Current_State is set to 0, indicating no movement.

```
While True:
```

The code then enters an ‘eternal’ loop, that will always run unless the interrupt keys are pressed.

```
Current_State = GPIO.input(PinPIR)
```

The Current_State is then set to the value of the input pin. If there is no movement, this will be `0`. If there is movement, this will be `1`.

```
# If the PIR is triggered
if Current_State==1 and Previous_State==0:
    print("  Motion detected!")
    # Record previous state
    Previous_State=1
```

If the PIR has been triggered, but on the last check it was not, then you will be notified by the message “Motion detected!”. The ‘previous state’ will then be set to show that motion has been detected.

```
elif Current_State==0 and Previous_State==1:
    print =("  Ready")
    Previous_State=0
```

If the current state shows that there is no movement, but the previous state shows that there was movement, then you will be notified that everything is still around the sensor with the message “Ready”.

```
# Wait for 10 milliseconds
time.sleep(0.01)
```

The code then sleeps for 0.01 of a second. This is here to stop the code from continuously flipping between seeing movement and not seeing movement.

```
except KeyboardInterrupt:
    print("  Quit")
    # Reset GPIO settings
    GPIO.cleanup()
```

If the interrupt keys are pressed (Ctrl+c), the program will end, but before it does, the GPIO pins will be reset to their default state.

Challenge:

Can you make the lights flash 3 times when motion is detected? Hint: reuse some of the code from part 3. However, create a variable that counts how many times the lights have flashed by initiating with value 0 before the loop starts. Instead of using a while True: loop, use a condition in which the loop will be executed provided the variable is <=3, and in each iteration add 1 to that variable.

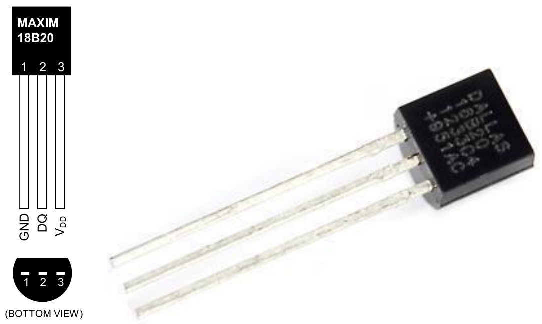
References:

The activities in this worksheet were adapted from CamJam Edukit Worksheets: https://camjam.me

Project 2 – Digital Thermometer

In this circuit, you will be connecting a temperature sensor to the GPIO header of your Raspberry Pi and using Python to measure the temperature where you put the sensor. Before you build the circuit, look at the additional parts you are going to use.

Temperature Sensor: The sensor supplied is a 'Dallas DS18B20'. The sensor has a '1-wire serial' interface, which means that it sends digital messages through its output pin to the Raspberry Pi. The Pi reads these messages and puts them in a 'device file', which is like a text file. You can read this file just as you would any other text file, although you cannot edit it.



When the Raspberry Pi has received a good message from the sensor, two lines will appear in the 'device file'. The first one will end in 'YES', and the second one will end in a 't=xxxxx', where 'xxxxx' is the temperature in 1/1000th of a degree Celsius. For example:

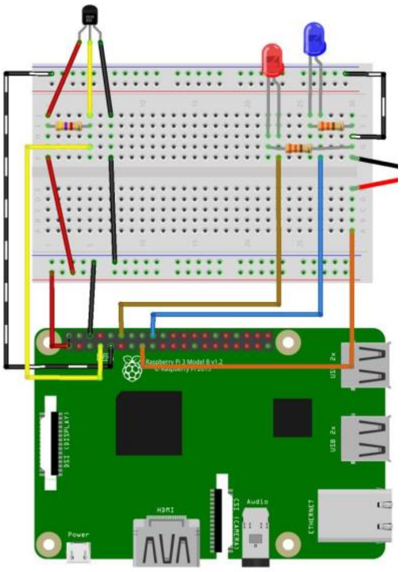
```
a3 01 4b 46 7f ff 0e 10 d8 : crc=d8 YES
a3 01 4b 46 7f ff 0e 10 d8 t=32768
```

This means that the temperature is 32.8°C.

The sensor has three wires (or legs); one is 'ground' (GND), the other one (V_{DD}) is for the power supply (3.3v), and the middle one (DQ) is the output from the sensor.

Resistor: The additional resistor used in this circuit is the 4.7kΩ (or 4700Ω) resistor. You can identify the 4.7kΩ resistor by the colour bands along the body. There will be either four or five colour bands on the resistor:

- If there are four bands, the colours will be Yellow, Purple, Red, and then Gold.
- If there are five bands, the colours will be Yellow, Purple, Black, Brown, Brown.



The resistor is used as a 'pull-up' for the data-line, and is required to keep the data transfer stable by supplying power to the signal circuit.

Part 1: Building the circuit:

You can keep the LEDs circuit from the PIR project in place as it will come handy later on.

Note: please ignore the orange line and the two red/black legs going out of the diagram on the left handside.

Before building this circuit, you must turn the Raspberry Pi off.

The circuit will be using another ‘ground’ (GND) pin to act like the ‘negative’ or 0 volt ends of a battery. One of the pins marked 3v3 will provide the power for the sensor. 3v3 means that it is a 3.3-volt power supply.

Use two female to male jumper wires to connect the GND and 3v3 GPIO pins to the bottom two rows of holes on the breadboard. Match up the colours marked on the breadboard - red and blue - with the jumper wires from the Pi – connect 3v3 to the red row, and GND to the blue row. These two ‘rails’ (as they are known) will provide the ground and power supply for the whole of the breadboard.

Connect the temperature sensor as shown, with a male/male jumper wire going to the bottom ‘rail’ attached to the Pi’s ground (GND). Connect the V_{DD} pin using a jumper to the 3v3 ‘rail’ at the bottom. This supplies the temperature sensor with its power.

The output (DQ) pin the sensor (the middle one) goes into a column with one end of the 4.7k Ω resistor and another jumper wire (shown in yellow) that goes to GPIO pin 4. The program will read the temperature from this pin.

The other end of the resistor should be inserted into another column of the breadboard, between the red lead of the temperature sensor and the jumper wire connected to the 3v3 ‘rail’.

Part 2: Configuring the Raspberry Pi

Before you can use any 1-wire devices, you must first tell the Raspberry Pi how to read them. Open a Terminal Window and type the following to edit the Raspberry Pi's configuration file:

```
sudo nano /boot/config.txt
```

Look to see whether there is a line that has '`dtoverlay=w1-gpio`' in it. If not, add the following to the end of the file:

```
   dtoverlay=w1-gpio
```

Now reboot the Pi:

```
sudo reboot
```

To test the configuration, type the following into a terminal window:

```
sudo modprobe w1-gpio
sudo modprobe w1-therm
cd /sys/bus/w1/devices
ls
```

This will list all the devices that are connected to the 1-wire interface. The Dallas DS18B20 sensor starts with '28-' followed by a long number. Type in the following, replacing the 'xxxx' with the text following the '28-':

```
cd 28-xxxx
cat w1_slave
```

In response, you should get the following showing that the DS18B20 is working:

```
a3 01 4b 46 7f ff 0e 10 d8 : crc=d8 YES
a3 01 4b 46 7f ff 0e 10 d8 t=32
```

Part 3: Coding

Now it is time to write the code. Open the IDLE3 editor and type in the following code:

```python
# Import Libraries
import os
import glob
import time

# Initialize the GPIO Pins
os.system('modprobe w1-gpio')  # Turns on the GPIO module
os.system('modprobe w1-therm') # Turns on the Temperature module

# Finds the correct device file that holds the temperature data
base_dir = '/sys/bus/w1/devices/'
device_folder = glob.glob(base_dir + '28*')[0]
device_file = device_folder + '/w1_slave'

# A function that reads the sensors data
def read_temp_raw():
    f = open(device_file, 'r') # Opens the temperature device file
    lines = f.readlines() # Returns the text
    f.close()
    return lines

# Convert the value of the sensor into a temperature
def read_temp():
    lines = read_temp_raw() # Read the temperature 'device file'

    # While the first line does not contain 'YES', wait for 0.2s
    # and then read the device file again.
    while lines[0].strip()[-3:] != 'YES':
        time.sleep(0.2)
        lines = read_temp_raw()

    # Look for the position of the '=' in the second line of the
    # device file.
    equals_pos = lines[1].find('t=')

    # If the '=' is found, convert the rest of the line after the
    # '=' into degrees Celsius, then degrees Fahrenheit
    if equals_pos != -1:
        temp_string = lines[1][equals_pos+2:]
        temp_c = float(temp_string) / 1000.0
        temp_f = temp_c * 9.0 / 5.0 + 32.0
        return temp_c, temp_f

# Print out the temperature until the program is stopped.
while True:
    print(read_temp())
    time.sleep(1)
```

Save the file and run it by pressing F5. The temperature measured by the sensor will be displayed. If you press the sensor between your fingers you will notice the temperature changing.

Challenge:

Alter the code to light the LEDs under the following conditions:

1. Light the blue LED when the temperature is below 36 °C.
2. Light the red LED when the temperature is above 36°C.

References:

The activities in this worksheet were adapted from CamJam Edukit Worksheets: https://camjam.me

C.2 Ethics

Information sheets

Student Information

As a participant of “Physical Computing” workshop on Raspberry Pi programming you are invited to be part of a research project about innovative approaches to teaching and learning science subjects in higher education.

What is the purpose of the research?

The aim of this research project is to evaluate the effectiveness of alternative ways of instruction (e.g. student-produced videos) used in this workshop as well as participants’ learning experiences during our workshops. This is done to ensure continuous improvement of the learning and teaching provision at Newcastle University.

Who is conducting this research?

This research is being conducted by Anna Vasilchenko and Fernando Russo Abegão as part of the “Physical Computing” project team. Other members of the project team include: Chris O’Malley, Jon Goss, Matthew Dyson, Richard Law, Rosemary Norman, Sharon Joyce, Harry Middleton, Peter Wrixon, Marie Devlin, Megan Venn-Wycherley, Helen Adamson, and Adam Rodgers. All team members are based in Newcastle University.

How specifically do I participate?

You are invited to take part in a focus group discussion. This will take place in Newcastle University and should be about 30 minutes long. The questions will concern your experience of the participation in the workshop. Your answers will be audio recorded.

What will happen to the information you collect about me?

Only people directly involved in this research will have access to the raw data we collect. The data will be stored securely on the protected filestore service. All the information will be anonymised and treated as confidential in that you will not be identified by your name, face or any other information. The audio recordings will be transcribed using certified transcription service, it may involve using AI tools for automation of the process. The anonymised data and resulting analysis may be used in academic and non-academic publications and presentations.

Are there any risks?

There is no risk in taking part in this study. The data collection will be managed to ensure it does not impact upon your learning experience and/or assessment in the university.

What if I change my mind or have questions?

You can ask questions, stop your participation, or withdraw completely from the research project at any time.

If after reading this information you decide to take part in the project, please, complete and sign the attached informed consent form and return it to Anna or Fernando.

If you have any questions, please don't hesitate to contact:

Anna Vasilchenko
a.vasilchenko@newcastle.ac.uk
Open Lab | School of Computing | Newcastle University
Urban Sciences Building |1 Science Square | Newcastle upon Tyne | NE4 5TG | UK

Instructor information for research project "Self-Flip Teaching & Learning in HE"

As part of our collaboration for the "Physical Computing" project, you are invited to be part of a research project about innovative approaches to teaching and learning. Before you decide to provide your consent for this, please take time to read the following information carefully.

What is this project about?

This research aims to study innovative methods of teaching and learning for STEM subjects in higher education. The main goal is to introduce *Self-Flipped teaching and learning* approach and test its feasibility. The proposed idea is about the reuse of student-generated content for teaching other students on the course. This could become an alternative method for the creation of teaching materials for the Flipped Classroom model. The construct of the "self-flip" stands from: "*self*" - the student-generated content and "*flip*"– the flipped classroom approach.

Who is conducting this research?

This research is being conducted by Anna Vasilchenko, a PhD student at Open Lab. Open Lab is an interdisciplinary research group in the School of Computing at Newcastle University, UK.

How specifically do I participate?

As a collaborator, you are invited to be part of the research by applying Self-Flip techniques as part of your teaching. We will discuss the development and application of the techniques together. After you have introduced the chosen self-flip techniques to your teaching we would like to evaluate your experience associated with the innovation. So, you will be invited to an interview which will run for up to one hour where we will talk about your teaching and the results of the self-flip technique application.

How will the information I give be kept and used?

Only the people directly involved in this research will have access to the raw data we collect. The data will be stored securely on the protected filestore service.

You will have a choice to **either** be fully **anonymised** so all the information about your participation will be treated as confidential and you will not be identified by name, **or** to be **named and credited** for your work within the study. The data and resulting analysis may be used in academic and non-academic publications and conference presentations.

Are there any risks?

This study is of minimal risk to you. If you feel distressed or uncomfortable as a result of participating in the project, you can bring this to the attention of Anna and she will ensure that every effort is made to address your concern and ensure the process to be an enjoyable experience for all involved.

What if I change my mind or have questions?

It's important that you know that at any time, even during or after the project you can ask questions, stop your participation, or withdraw completely. After reading this information, if you would like to take part in the project, please complete the attached informed consent form. You will be provided with a copy of the form for your own records and another copy will be kept by a member of the project team.

If you have any questions, please don't hesitate to contact:

Anna Vasilchenko

a.vasilchenko@newcastle.ac.uk

Open Lab | School of Computing | Newcastle University

Urban Sciences Building |1 Science Square | Newcastle upon Tyne | NE4 5TG | UK

Consent forms

Student consent form for a research interview as part of the project

"Self-Flip Teaching & Learning in Higher Education"

I, the undersigned, confirm that *(please tick box as appropriate)*:

☐ I have read and understood the information about the project, as provided in the Information Sheet.

☐ I have been given the opportunity to ask questions about the project and my participation in it.

☐ I voluntarily agree to my participation in this study.

☐ I understand I can withdraw my participation for at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.

☐ I understand that my participation in the focus group discussions will be audio recorded.

☐ I understand that audio recording and transcription from the focus group will be stored securely on the protected filestore service.

☐ I understand that other researchers from Newcastle University, who are part of the project team, may have access to the anonymised information collected and that the researchers will follow the agreed procedures for the data processing and storage as detailed on the Information Sheet.

☐ I understand that anonymised direct and indirect quotes from my interview may be used in written academic and non-academic publications and conference presentations about the research project.

Name (please print):

Signature: Date:

Instructor consent form for a research interview as part of the project

"Self-Flipped Teaching & Learning in Higher Education"

I, the undersigned, confirm that (please tick box as appropriate):

☐ I have read and understood the information about the project, as provided in the Information Sheet.

☐ I have been given the opportunity to ask questions about the project and my participation in it.

☐ I voluntarily agree to my participation.

☐ I understand I can withdraw my participation at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.

☐ I understand that other researchers in the project team will have access to the information collected and that the researchers will follow the agreed procedures for the storage of the data as detailed on the Information Sheet.

☐ I understand that I will be interviewed for the study and that this interview will be audio recorded.

☐ I understand that audio recording and transcription from the interview will be stored securely on the protected filestore service.

☐ I understand that anonymised direct and indirect quotes from my interview may be used in written academic and non-academic publications and conference presentations about the research project.

☐ I understand that the project leads will protect my identity by not referring to me by name in any of the dissemination of the data or results.

☐ I would like to be offered the option of being named and credited in references to my participation in the development and testing of the Self-Flip techniques.

Name:

Signature: Date:

C.3 Research Tools

Interview questions

Instructor interview

- Can you tell me a little bit about yourself, your teaching experience in general + flipped teaching, etc? (Some demographic information about teacher background)
- Do you have any flipped classroom teaching experience?
- What do you think in general about Self-Flip?
- How easy or difficult it was for you to incorporate student-created materials into the teaching?
- Was it less or more difficult to plan the course curriculum with these materials in comparison to your normal teaching? Any lessons learn or other recommendation that you would like to share with me or other instructors in order to help them with similar difficulties?
- What do you think these materials have added to your normal teaching?
- In your opinion what are the benefits for students to see and learn from the student-created materials?
- Are you satisfied with the outcomes of the workshops in general? How do you think the use of student-created material impacted the results?
- What would you do differently next time?
- If you are to set up a course with student content creation. How easy or difficult do you think it would be to set up the assessment task for a new cohort in order to not repeat the last year submission but to build the new content?
- Is there anything else you would like to add?

Focus Group questions

Student Focus Group protocol

Part 1

Flipped Classroom and content creation experience

- Do you have any experience with Flipped Classroom teaching & learning format?
- Do you have any experience with creation of learning materials? Videos in particular?
- Did you watch the videos we asked you to watch before this workshop?
  - How many? Why?
- What do you think of those videos in general?
- *What do you think could be a good motivation for students to watch such videos before classes/workshops?*

Part 2

Learning from student-produced videos

(Follow up of the answers from the survey)

- Was it easy to learn from the video that other students have created?
- Would you prefer the same materials are made by your instructor?
- What did you like about the materials?
- Was there anything you disliked?
- How would you make them better?
- Do you think they helped you learn the content better or worse in comparison to other resources available during the workshop?
- What do you think of the technical qualities of the videos?
- How would you improve them?
- Do you think you could do better work yourself if you have the same task as a course assignment?
- Did you have any doubts with regards to the content delivered in these materials?
- Is there anything else we should have asked you?
- Any additional comments?

Survey questionnaires

This appendix includes pre- and post-workshops questionnaires used in the Physical Computing project.

Questionnaire 1

Python for Raspberry Pi (questionnaire 1)

Welcome to the "Python for Raspberry Pi" workshop!

Please fill in this quick questionnaire before you start you activities. All your answers will be anonymous, they will help us to improve our future workshops and understand the impact of the Physical Computing project in general.

If you have any questions please contact: Anna Vasilchenko (a.vasilchenko@newcastle.ac.uk) or Fernandc Russo Abegão (Fernando.Russo-Abegao@newcastle.ac.uk).

* Required

1. What level would you consider your programming skills, on a scale of 1 (Complete novice) t 5 (Experienced)? *

	1	2	3	4	5	
Complete novice	◯	◯	◯	◯	◯	Experienced

2. Describe your previous programming experiences, including any programming languages you might have used.

3. If you were to give yourself a score from 1 to 10, at what level would you rate your programming confidence? *

Mark only one oval.

1	2	3	4	5	6	7	8	9	10
⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭	⬭

4. Is there anything you have wanted to try creating, but felt that a lack of programming skill prevented this? If so, what was the project?

5. What made you interested in taking part in this session today?

Done! Thank you for your answers!

Now let's get started with the workshop activities.

Questionnaire 2

Raspberry Pi Workshop

Thank you for agreeing to take part in this survey!

Newcastle University strives to provide cutting edge education to its students. Instructors in the Schools of Computing and Engineering are working on improving their teaching methods. That is why you are invited to take part in this survey which aims at understanding your experiences at Raspberry Pi workshop and your attitude towards learning from peer-created materials.

This workshop is one of the series of workshops within Physical Computing project. Your answers will help us to improve future workshops and understand the impact of the project in general. The video tutorials used in this workshop were created by Computing Science students. We would like to know your experience of learning from them. Please fill this quick survey and let us know your thoughts (your answers will be anonymous).

If you have any questions please contact: Anna Vasilchenko (a.vasilchenko@newcastle.ac.uk).

* Required

Part 1: A little bit about yourself

1. **1. I currently study at my** *
   Mark only one oval.
   - First year
   - Second year
   - Third year
   - Placement year
   - Other: ____________________

2. **2. My major is** *
   Mark only one oval.
   - Computing Science
   - Electrical and Electronic Engineering
   - Chemical Engineering
   - Civil Engineering
   - Mechanical Engineering
   - Marine Technology
   - Surveying, Mapping and Geographical Information Systems (GIS)
   - Other: ____________________

3. **3. I am** *
Mark only one oval.

- ⬭ Female
- ⬭ Male
- ⬭ Prefer not to say
- ⬭ Other: ____________________

4. **4. I am ____ years old** *
Mark only one oval.

- ⬭ Younger than 18
- ⬭ 18-19
- ⬭ 20-21
- ⬭ 22 and older

5. **5. I am originally from** *
Mark only one oval.

- ⬭ UK
- ⬭ Other: ____________________

Part 2: About the workshop

6. **1. I find the content of this workshop interesting** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

7. **2. This workshop improved my understanding of computer programming** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

8. **3. I would like Physical Computing topics to be embedded into regular computer programming modules** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

9. **4. Describe a part of the workshop that you found most interesting. Why did you enjoy it?**

10. **5. If you could improve the workshop, what would you change or add?**

11. **6. Was there anything you would have liked to cover which wasn't included in this workshop? What would it have been?**

12. **7. Now that you have completed the session, if you were to give yourself a score from 1 to 10, at what level would you rate your programming confidence?**
Mark only one oval.

1	2	3	4	5	6	7	8	9	10
◯	◯	◯	◯	◯	◯	◯	◯	◯	◯

13. **8. How would you feel if you were asked to teach a friend these activities? Are there any resources you feel you would need? Or any further Raspberry Pi sessions?**

14. **9. What else do you feel could be done to help support your programming skills?**

15. **10. Are there any other comments that you would like to share, that weren't covered by the questions above?**

16. **11. Is there something you would like to know how to create? Is there a project you're interested in working towards?**

Start this form over.

Part 3: Learning from videos made by students

17. **1. It was very easy to learn from the video tutorials that were used in this workshop** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

18. **2. The video tutorials helped me learn the content better in comparison to other resources available during the workshop** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

19. **3. I would prefer the same video tutorials were made by an instructor** *
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

20. **4. I liked about this video tutorials ...** *
Write a couple of things that were particularly good or helpful to you

21. **5. I disliked about this video tutorials ...** *
Write a couple of things that were particularly unhelpful or annoying to you

22. **6. I would you make them better by ...** *
Write any suggestions for future students, who would make similar materials. Focus here on content delivery, not technical qualities of the videos.

23. **7. I think technical qualities of the videos were ...** *
Comment here on anything from: photographic qualities (light or dark, steady or shaky, in or out of focus), sound qualities (voice of the narrator, background noise), pace of the narration, editing of the video or anything else. In your opinion, was it good or bad?

24. **7.1. If in previous question you commented negatively on any of the video qualities. Would you agree or disagree that those flaws had a negative impact on your learning from those videos?**

If you commented positively in previous question, ignore this one.
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

25. **8. How would you improve the technical qualities of the videos?** *

If you have any, write your suggestions for future students, who would make similar materials.

26. **9. Do you think you could create a better video yourself?** *

Imagine that as part of your coursework you are asked to create instructional materials (like these video tutorials) for someone else to learn from.
Mark only one oval.

- ⬭ Yes
- ⬭ Maybe
- ⬭ No

27. **10. Did you have any doubts with regards to the content delivered in these video tutorials?** *

Would you agree or disagree that when watching the video tutorials you thought that the students may present an incorrect information in them.
Mark only one oval.

	1	2	3	4	5	
Strongly disagree	⬭	⬭	⬭	⬭	⬭	Strongly agree

28. **10.1. Why did you think so?** *

Explain, please, why did you trust or doubt the tutorials.

29. **If you have any additional comments or thoughts, please, write them here.**

Done! Thank you very much for your answers!

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Appendix D. Case Study B materials

D.1 Context

Uppsala course outline

Syllabus for Complex IT Systems in Large Organisations - Uppsala University, Sweden

UPPSALA UNIVERSITET

Syllabus for Complex IT Systems in Large Organisations

Komplexa IT-system i stora organisationer

A revised version of the syllabus is available.

5 credits
Course code: 1DL630
Education cycle: Second cycle
Main field(s) of study and in-depth level: Computer Science A1F, Technology A1F
Grading system: Fail (U), Pass (3), Pass with credit (4), Pass with distinction (5)
Established: 2017-03-09
Established by: The Faculty Board of Science and Technology
Applies from: week 30, 2017
Entry requirements: 120 credits including Software Engineering, Advanced Software Design and Requirements in Agile Development.
Responsible department: Department of Information Technology

LEARNING OUTCOMES

To pass the course, the student should be able to

- describe the challenges and problems that arise in connection with the development and introduction of IT systems in large organisations, and methods to deal with these
- describe the challenges and problems that occur during procurement or development of systems intended for different user groups, and methods to deal with these
- discuss advantages, disadvantages and applicability of a method in a specified problem situation
- propose appropriate IT solution for a given problem situation and motivate and discuss the solution
- present and discuss course contents verbally and in writing with proficiency appropriate to the level of education.

CONTENT

Complexity problems that arise in large organisations where different user groups have different requirements. Development and implementation of IT solutions with multiple interoperable systems and management of the effects of prolonged contnuous updates and maintenance of such systems. Legacy code.

INSTRUCTION

Lectures, tutoring.

ASSESSMENT

Verbal and written presentation of assignments and cases.

READING LIST

The reading list is missing. For further information, please contact the responsible department.

D.2 Ethics

Information sheets

Student information for research project

"Self-Flip Teaching & Learning in Higher Education"

As a student who studied the "Complex IT systems in large organisations" course in spring semester 2018, you are invited to be part of a research project about innovative approaches to teaching and learning science subjects in higher education.

What is the purpose of the research?

The aim of this research project is to evaluate the effectiveness of alternative ways of teaching and assessment (e.g. collaborative video production) used in this course as well as students' learning experiences during the course. This is done to ensure continues improvement of the learning and teaching provision at your university.

Who is conducting this research?

This research is being conducted by Anna Vasilchenko from Newcastle University, UK, in collaboration with Mats Daniels, Åsa Cajander and Diane Golay from Uppsala University, Sweden.

How specifically do I participate?

You are invited to take part in an interview. This will take place in Uppsala University and should be about 30 minutes long. The questions will concern your experience of the course. Your answers will be audio recorded.

What will happen to the information you collect about me?

Only the people directly involved in this research will have access to the raw data we collect. The data will be stored securely on the protected filestore service. All the information will be anonymised and treated as confidential in that you will not be identified by your name, face or any other information. The anonymised data and resulting analysis may be used in academic and non-academic publications and presentations.

Are there any risks?

There is no risk in taking part in this study. The data collection will be managed to ensure it does not impact upon your learning experience and/or assessment.

What if I change my mind or have questions?

It's important that you know that at any time you can ask questions, stop your participation, or withdraw completely from the research project.

After reading this information, and if you decide to take part in the project, at the beginning of the interview you will be asked to complete and sign the attached informed consent form.

If you have any questions, please don't hesitate to contact:

Anna Vasilchenko
a.vasilchenko@newcastle.ac.uk
Open Lab | School of Computing | Newcastle University
Urban Sciences Building |1 Science Square | Newcastle upon Tyne | NE4 5TG | UK

Instructor information sheet for research project
"Self-Flip Teaching & Learning in HE"

As part of our collaboration for the module "Complex IT systems in large organisations", you are invited to be part of a research project about innovative approaches to teaching and learning. Before you decide to provide your consent for this, please take time to read the following information carefully.

What is this project about?

This research aims to study innovative methods of teaching and learning for STEM subjects in higher education. The main goal is to introduce *Self-Flipped teaching and learning* approach and test its feasibility. The proposed idea is about the reuse of student-generated content for teaching other students on the course. This could become an alternative method for the creation of teaching materials for the Flipped Classroom model. The construct of the "self-flip" stands from: "*self*" - the student-generated content and "*flip*"– the flipped classroom approach.

Who is conducting this research?

This research is being conducted by Anna Vasilchenko, a PhD student at Open Lab. Open Lab is an interdisciplinary research group in the School of Computing at Newcastle University, UK.

How specifically do I participate?

As a collaborator, you are invited to be part of the research by applying Self-Flip techniques as part of your teaching. We will discuss the development and application of the techniques together. After you have introduced the chosen self-flip techniques to your teaching we would like to evaluate your experience associated with the innovation. So, you will be invited to an interview which will run for up to one hour where we will talk about your teaching in the module and the results of the self-flip technique application.

How will the information I give be kept and used?

Only the people directly involved in this research will have access to the raw data we collect. The data will be stored securely on the protected filestore service.

You will have a choice to **either** be fully **anonymised** so all the information about your participation will be treated as confidential and you will not be identified by name, **or** to be **named and credited** for your work within the study. The data and resulting analysis may be used in academic and non-academic publications and conference presentations.

Are there any risks?

This study is of minimal risk to you. If you feel distressed or uncomfortable as a result of participating in the project, you can bring this to the attention of Anna and she will ensure that every effort is made to address your concern and ensure the process to be an enjoyable experience for all involved.

What if I change my mind or have questions?

It's important that you know that at any time, even during or after the project you can ask questions, stop your participation, or withdraw completely. After reading this information, if you would like to take part in the project, please complete the attached informed consent form. You will be provided with a copy of the form for your own records and another copy will be kept by a member of the project team.

If you have any questions, please don't hesitate to contact:

Anna Vasilchenko

a.vasilchenko@newcastle.ac.uk

Open Lab | School of Computing | Newcastle University

Urban Sciences Building |1 Science Square | Newcastle upon Tyne | NE4 5TG | UK

Consent forms

Student consent form for research interview as part of the project

"Learning & Teaching in Higher Education"

I, the undersigned, confirm that *(please tick box as appropriate)*:

☐ I have read and understood the information about the project, as provided in the Information Sheet.

☐ I have been given the opportunity to ask questions about the project and my participation in it.

☐ I voluntarily agree to my participation.

☐ I understand I can withdraw my participation for at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.

☐ I understand that other researchers from Newcastle and Uppsala universities, who are part of the project team, may have access to the anonymised information collected and that the researchers will follow the agreed procedures for the storage of the data as detailed on the Information Sheet.

☐ I understand that I will be interviewed for the study and that this interview will be audio recorded.

☐ I understand that audio recording and transcription from the interview will be stored securely on the protected filestore service.

☐ I understand that anonymised direct and indirect quotes from my interview may be used in written academic and non-academic publications and conference presentations about the research project.

Name (please print):

Signature: Date:

Instructor consent form for research interview as part of the project

"Self-Flipped Teaching & Learning in Higher Education"

I, the undersigned, confirm that (please tick box as appropriate):

- [ ] I have read and understood the information about the project, as provided in the Information Sheet.

- [ ] I have been given the opportunity to ask questions about the project and my participation in it.

- [ ] I voluntarily agree to my participation.

- [ ] I understand I can withdraw my participation at any time without giving reasons and that I will not be penalised for withdrawing nor will I be questioned on why I have withdrawn.

- [ ] I understand that other researchers in the project team will have access to the information collected and that the researchers will follow the agreed procedures for the storage of the data as detailed on the Information Sheet.

- [ ] I understand that I will be interviewed for the study and that this interview will be audio recorded.

- [ ] I understand that audio recording and transcription from the interview will be stored securely on the protected filestore service.

☐ I understand that anonymised direct and indirect quotes from my interview may be used in written academic and non-academic publications and conference presentations about the research project.

☐ I understand that the project leads will protect my identity by not referring to me by name in any of the dissemination of the data or results.

☐ I would like to be offered the option of being named and credited in references to my participation in the development and testing of the Self-Flip techniques.

Name:

Signature: Date:

D.3 Research Tools

Interview questions

Student interview questions

To note the type of student (UG, PG…), and basic demographic information (gender, country of origin).

- What is your general attitude to this course? What do you think of it?
- What do you think of the format of the course? Especially, the part of making video and learning from something which is not a textbook or an instruction.
- Were you prepared for this kind of coursework?
- How did you find learning from the materials (video, etc.) that other students have created?
- Would you prefer the same materials are made by your instructor?
- What did you like about students-made videos?
- Was there anything you disliked?
- How would you make those videos better?
- Do you think the videos helped you learn the content better or worse in comparison to other resources available during the course?
- What do you think of the technical qualities of the videos?
- How would you improve them?
- Do you think your work was better than the work of others?
- Did you ever have any doubts about the information which was delivered through those videos made by students?
- How this method of the teaching affected your workload on the course?
- Is there anything else I should have asked you?
- Do you have any more comments to add?

Instructor interview questions

Ask basic demographic information about the instructor background.

Usefulness of the materials for teaching

1. How easy or difficult it was for you to incorporate student-created materials into the teaching?
2. Was it less or more difficult to plan the course curriculum with these materials in comparison to your normal teaching? Any lessons learn or other recommendation that you would like to share with me or other instructors in order to help them with similar difficulties?
3. What do you think these materials have added to your normal teaching?
4. In your opinion what are the benefits for students to see and learn from the student-created materials?
5. How easy or difficult do you find to set up the assessment task for a new cohort in order to not repeat the last year submission but to build the new content?

Reflection on the tests results to see if students have learned what was expected from them

6. (If pre- and post- test available) What is your thought about the tests results? Are you satisfied with the outcomes? How do you think the use of student-created material impacted these results?
7. What would you do differently next time?
8. Is there anything else you would like to add?