Ethics Education in UK Computing Degrees: Current Practices and a Collaborative Solution

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Abstract

Despite the recent growth in the number of ethical dilemmas related to information and data technologies, there is still little research published on the approaches used to deliver ethics training to computer science undergraduates in the United Kingdom. Although British universities seem to cover a substantial amount of ethics material in their computing curricula, the American higher education system has put significantly more effort into integrating such ideas into the main, technological subjects of these degrees. Hence, the question arises, what is the current state of ethics integration in computing degrees in the UK and what can be done to execute it more effectively. This work investigates the extent to which such topics are taught in the UK based on the review of available data, literature, and interviews with numerous lecturers. To address the established problems, a solution is proposed in the form of a system enabling resource sharing and curriculum mapping, and later evaluated by experts and potential users. The combination of qualitative and quantitative methods of user-centred design was employed and resulted in a robust prototype of a system that can be used and developed further for the academic community.

Research Ethics Approval

This project obtained approval from the Informatics Research Ethics committee.
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The participants' information sheet and a consent form are included in the appendix.

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(*Zofia Kniter*)

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Chapter 1

Introduction

1.1 Motivation

With the recent growth in the development of widely used AI tools, there have been growing concerns surrounding the ethical implications of introducing such tools to the public [3]. After increased criticism for the introduction of these machine learning algorithms, numerous Big Tech companies have decided to introduce Ethics Teams in their structures. However, there have been reports that most of these teams are being majorly cut down and these efforts have been labelled the case of "ethics washing" [4, 5]. This is also not the first time we have seen how technical innovations can unwittingly cause harm rather than good. From 1999 to 2015 more than 700 post office operators were charged with theft, fraud and false accounting due to an error in a software system introduced in the late 1900s [6]. These examples show how easily new technological advancements can become harmful and unethical. For these reasons, we must ensure that all computer science graduates are equipped with the skills and ethical frameworks to critically analyse the impact their innovations could have on the public.

In recent years several North American universities (mostly in the US) have chosen to integrate computer ethics throughout their degree programmes [7, 8, 9, 10, 11]. This was achieved by introducing an innovative approach which entails philosophers and computer scientists collaborating to embed ethics in existing computer science courses [7]. This will be discussed in detail in the literature review. However, it seems that Europe is falling behind and there is little research on how these topics are being taught to future computer scientists in the region [1]. Thus, it is crucial to understand how educators in the United Kingdom deliver ethics training to computer science undergraduates and what they decide to teach. For the outlined reasons, this project aims to investigate approaches used to teach computer ethics at different institutions in the United Kingdom. This research focuses solely on undergraduate degrees (including integrated master's). It also outlines the development process for a tool addressing some of the challenges course organisers face when advocating for the integration of ethics in computer science degree programmes.

1.2 Research Questions

RQ1: What are the available tools and approaches used in delivering ethics training to computer science undergraduates?

RQ2: What approaches are most widely used by higher education institutions in the United Kingdom?

RQ3: Which approaches for displaying curriculum maps are most effective?

RQ4: What are the requirements of the tool?

> **RQ4.1:** How should it combine resources for delivering ethics training and curriculum mapping?

RQ5: To what extent does the tool meet the requirements and support staff members and students in improving ethics training for computer science students?

> **RQ5.1:** Does the tool encourage a more collaborative approach to course and degree programme design?

1.3 Contributions

This section provides a list of the main contributions that emerged as part of this project:

- Investigated available resources on computer ethics education and approaches used to deliver it to undergraduate students.
- Analysed curriculum mapping as a way of assessing curricula.
- Investigated approaches to teaching computer ethics most commonly used in the United Kingdom. This study consisted of surveying chosen institutions in the UK, interviewing 5 ethics educators from across the country and analysing curricula obtained through the survey.
- Identified issues commonly faced by computer scientists who try to weave ethics throughout the computer science degree programmes.
- Gathered requirements for a tool which attempts to address some of these issues by creating a collaborative resource for ethics activities, e.g. lectures, assignments, case studies. The tool also enables course organisers and programme designers to view curriculum maps for ethics topics currently delivered within computer science degrees.
- Designed a low-fidelity prototype for the tool in Figma [12].
- Conducted a cognitive walkthrough with 2 former HCI students and evaluated the design with 3 experts in HCI and education to identify potential usability issues and decide on the curriculum map users interact best with.
- Implemented the high-fidelity prototype for the tool in React.

- Evaluated the final version of the tool with 3 experts in HCI and education, and 5 informatics students in terms of usefulness and usability. Concluded if the tool is acceptable using the System Usability Scale.

1.4 Structure of the Report

Chapter 1 motivates why the topic for the project was chosen and outlines the contributions of the work. It also establishes the research questions which guided this project.

Chapter 2 critically reviews the currently available literature on computer ethics and its pedagogy at higher education institutions. It also investigates available online resources on computer ethics education and describes how curriculum maps are used in assessing programmes and course curricula.

Chapter 3 outlines the study conducted to understand approaches to teaching computer ethics currently used at higher education institutions in the United Kingdom. Critically analyses results of the questionnaire and interviews with computer ethics course organisers. Describes the process of conducting a curriculum analysis on collected computer ethics syllabi.

Chapter 4 describes the process of gathering requirements for the tool and provides a comprehensive list of the identified requirements.

Chapter 5 introduces the design for the low-fidelity prototype with all its functionalities. Explains the cognitive walkthrough carried out with 2 former HCI students and a prototype evaluation conducted with 3 HCI and education experts. Provides insights into the impact of the studies on the final version of the tool.

Chapter 6 describes the design for the high-fidelity prototype and all the included features. Provides insights into the evaluation of the tool in terms of usability and usefulness to determine if the final prototype is viable.

Chapter 7 provides conclusions for the final work. Answers the established research questions, critically analyses project limitations and presents ideas for future work.

Chapter 2

Literature Review

*This chapter aims to provide historical context for computer ethics and its pedagogy. It also gives insights into tools with resources on ethics in computer science. Curriculum mapping as a way of assessing degree and course programmes will also be explored in this chapter. Thus, it attempts to answer **RQ1**.*

2.1 Terminology

To resolve any ambiguities in terminology, these definitions were established and will be consistently used throughout the report. All definitions are rooted in the context of this work.

Degree - a programme of study delivered at a university, e.g. BSc Computer Science.

Course - a set of classes offered as part of a degree programme.

Submodule - a set of classes which are part of a course.

Activity - a component included in a course, e.g. a lecture, an assignment, a case study etc.

Module - a component included in a course. Will only be used during the literature review to address modules developed by the embedded ethics teams and in the low-fidelity prototype design. The ambiguity of this term will be addressed in chapter 5.

2.2 Computer ethics

The first mentions of ”computer ethics” appeared in the 1950s, when Norbert Wiener published a book called The Human Use of Human Beings [13]. Even though, at that point, he did not use the term ”computer ethics”, he did lay out a foundation for it [14]. Despite the importance of his work, it was ignored by other researchers until the 1960s, when Donn Parker headed the development of the first Code of Professional Conduct of the Association for Computing Machinery [15]. In the mid-1970s Walter Manner

noticed that including technology in issues related to medical ethics expands the present discussion and adds more cases that require more in-depth consideration [14]. Thus, he coined the term computer ethics and developed a course on the topic.

Throughout the years, many academics have tried to predict the future of computer ethics. Krystyna Gorniak-Kocikowska argued that computer ethics will eventually evolve into the notion of global ethics encompassing other ethical theories, thus making it applicable to all cultures on earth [16]. Similarly to Gorniak, Deborah Johnson believed that computer ethics would eventually cease to exist. However, according to Johnson, as information technology eventually enters every aspect of human existence, we will no longer notice its presence, thus making the term computer ethics obsolete [17]. According to Bynum, these views combined, predict ”a future in which what we call ‘computer ethics’ today is globally important and a vital aspect of everyday life, but the name ‘computer ethics’ or ‘information ethics’ may no longer be used”[14].

2.3 Current views on teaching computer ethics

Since then computer ethics has become an integrated part of computer science with many academics making an effort to ensure it is also an integrated part of computer science curricula. Despite the ACM’s Curriculum from 1978 exhibiting ambivalence towards teaching computer ethics, Miller in 1988 argued that ”technical issues are best understood [...] in their social context, and the societal aspects of computing are best understood in the context of the underlying technical detail.”[18] Even back then Miller identified some challenges the departments will face when teaching computer ethics, such as overcrowded curricula and lack of ethics experience within computer science faculty, which can lead to professors falling ”into a trap of preaching a moral code”[18]. Currently, numerous universities choose to include computer ethics training in their curricula. In 2006 Quinn surveyed 50 colleges and universities accredited by ABET’s Computing Accreditation Commission in the US, which requires coverage of computer ethics [19]. Quinn concluded that 15% of these institutions meet the criteria by requiring students to take an ethics course outside of the computer science department, typically philosophy while 55% deliver a compulsory course on ethics within the department. The remaining 30% incorporate discussions on ethics within different computer science courses. Quinn also pointed out that some institutions choose to deliver a dedicated course within their department to ease the process of proving they fulfil ABET’s criteria. Some institutions explained that it is harder to enforce incorporating assessments on ethics within other computer science courses. Quinn also addressed the challenge identified by Miller on whether computer scientists should be the ones to cover ethics material. Quinn argued that outsourcing ethics to philosophy departments will deprive students of interacting with computer scientists who ”do ethics”[19]. Quinn also acknowledged that computer science professors might feel uncomfortable with teaching moral values and do not have the expertise to teach ethics. The issue of who should be teaching computer ethics was addressed by the Embedded EthiCS team at Harvard [7] where it was decided to introduce a collaboration between computer scientists and philosophers when teaching computer ethics. This approach will be further discussed in section 2.4.

2.3.1 The European Survey [1]

As mentioned in Section 1.1 much of the currently available literature comes from North America (primarily the US). For this reason, most of the available insights into computer ethics pedagogy come from a context not necessarily applicable to Europe. To attempt to bridge that gap in research, a European survey was conducted, which reached 152 European Universities from 30 different countries. Overall, 61 institutions completed the survey, representing 23 European Countries. Since only 3 institutions exclusively offer postgraduate programmes, the survey is relevant in the context of undergraduate degrees, which are considered in this project.

The survey revealed that 22 responses out of 61 came from institutions which did not teach computer ethics at all. Of these 22 responses, 63% indicated that they believed teaching ethics was *Important* or *Very important*. When asked to outline reasons as to why ethics is not taught at their institutions, 73% indicated that it was due to lack of time and staff availability with 50% also specifying lack of staff expertise as another issue. Despite some respondents indicating that teaching ethics is not important, these results show that the majority of higher education institutions believe computer ethics to be a topic which should be delivered to computer science students.

When it comes to the approaches that are most widely used, 28% of the respondents thread ethics throughout several courses while 38% deliver a standalone course; with 33% offering a combination of both approaches.

2.3.2 BCS Accreditation

When understanding the context of current computer ethics pedagogy, it is also important to consider requirements that institutions seeking accreditation in the United Kingdom must meet. To obtain accreditation from the British Computer Society for undergraduate and integrated masters programmes, graduates must be assessed on the ability to ”Recognise the legal, social, ethical, and professional issues involved in the exploitation of computer technology and be guided by the adoption of appropriate professional, ethical and legal practices.”[20]

2.4 The Embedded EthiCS approach

The Embedded EthiCS approach was first piloted in 2017 at Harvard by computer scientist Barbara Grosz and philosopher Alison Simmons [7]. Their main goal was to incorporate mini-modules on ethics into already existing computer science courses to provide a clear link between these two disciplines. Thus, students were exposed to important ethical issues and frameworks while learning new technological concepts, e.g., coding or implementing algorithms, allowing them to view ethics as an integrated part of computer science. The mini-modules were designed and delivered in collaboration with graduate students and postdoctoral philosophers. Such interdisciplinary nature of the proposed approach addressed an important issue with stand-alone courses, which are often taught from within the discipline and can be exclusionary [21]. Since the introduction of Embedded EthiCS at Harvard, multiple institutions across North

America have chosen to incorporate this approach in their curricula [8, 9, 10, 11] and report on the student attitudes towards this approach. At the University of Toronto St.George, it was found that the modules ”successfully increased students' mean level of interest in ethical issues and self-efficacy in dealing with ethical issues.” [9] Stanford also obtained positive feedback from the students, with one commenting ”I loved the inter-disciplinary aspect of the class. As a CS major, I've been frustrated by how similar so many of my required classes have felt [...]” [8], which suggests students' need for more interdisciplinary approaches.

Despite the success of the program in North America, it has not yet been introduced in the United Kingdom. This could be caused by some issues that can arise when incorporating such an approach. Some of the difficulties mentioned by the team at Harvard include insecurities related to the lack of expertise in a field, which is foreign to the contributors (both computer scientists and philosophers), differing methodologies and vocabularies used in the fields of ethics and computer science, as well as some institutional challenges, which created financial and administrative barriers during the process [7]. Contributors to the Computing Ethics Narratives, also identify a lack of evaluation of embedded ethics effectiveness and resistance coming from CS faculty members, as other obstacles embedded ethics teams might face when trying to implement this approach at their institutions [22]. Section 3.3.4.2 will attempt to put the outlined issues into the context of higher education institutions in the United Kingdom, to discuss the reasons for this approach not yet being used in the country.

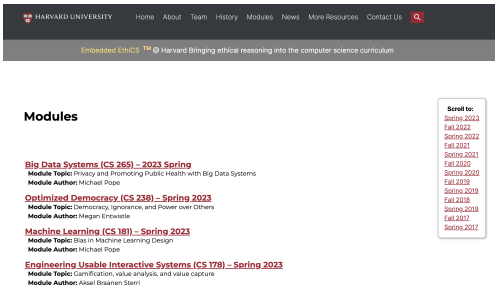
2.4.1 Available tools

As mentioned earlier numerous institutions in North America chose to incorporate the Embedded EthiCS approach into their curricula. Some of these institutions share the modules they design through online databases. These were investigated and compared, to gather insights into features that similar tools should have and to discuss reasons for the need for the proposed tool.

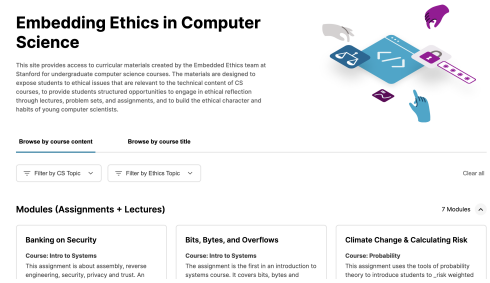
Figure 2.1 provides screenshots of the main pages which include modules and resources from five different universities. Figures a, b and c show websites created by Harvard, Stanford and the University of Toronto St.George respectively. All of these pages serve a similar purpose and include modules and resources developed by the embedded ethics teams at these institutions. Figure d shows a page developed in collaboration between Colby College and Bowdoin College and includes exemplar modules, as well as extra resources varying from blog posts and news articles to TED talks and documentaries.

Even though these tools offer a variety of resources, there are some limitations to how these could be used by course organisers in the United Kingdom. Since all of these were created by institutions based in North America (mostly the US), they lack examples specifically related to the United Kingdom. Since the approach of case-based analysis of unethical practices is widely used, it is useful to discuss cases and examples that students would be able to relate to [19]. Thus, it would be useful to provide a resource that is rooted in the appropriate context of British universities. All of the provided modules are also related to the courses taught at a given institution. For this reason, most of these would have to be adapted and changed to fit the curricula available at

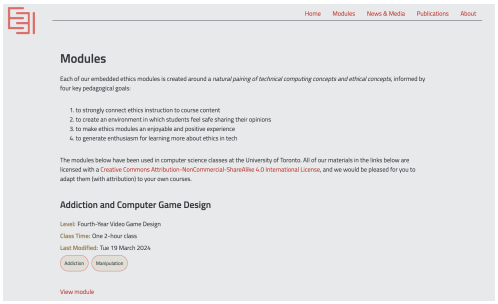
universities in the United Kingdom.



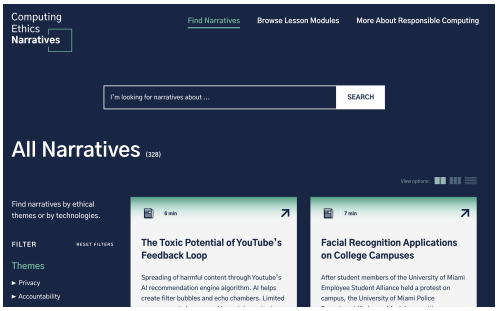
(a) Embedded EthiCS @ Harvard [23]



(b) Embedded Ethics at Stanford [24]



(c) Embedded Ethics at St.George [25]



(d) Computing Narratives [26]

Figure 2.1: Available technological solutions

2.5 Curriculum mapping

Curriculum assessment is a critical analysis performed to evaluate course and programme syllabi. Curriculum maps are often used as frameworks which guide curriculum assessments to create clear and easy-to-interpret visualisations of the content of degree programmes and courses. They are often used to map course/degree content against a set of predefined requirements or compare multiple different curricula [27]. Additionally, they linearly show when certain topics and skills are expected to be delivered to students [28]. Thus, they allow the programme designers to see any potential gaps and redundancies in the curricula, which can be further consulted and discussed. This further supports ”participant collaboration in curriculum development and assessment” [29], thus making curriculum mapping useful for schools and universities. Currently, the process of creating such maps is often carried out for accreditation and accountability purposes. [28]

Some studies were conducted to analyse the effectiveness of these maps with one suggesting that they are ”necessary, but not sufficient, to fully assess the appropriateness and alignment of a programme or course.” [29] The same study explained that these maps can provide ”a high-level overview of the intent of a programme or course” [29] but do not give concrete proof of the content and the rigour of assessment.

Chapter 3

Pedagogy of computer ethics in the United Kingdom

*This chapter describes the investigation into approaches to teaching computer ethics used in the United Kingdom. It outlines the results of the questionnaire, interviews with computer ethics course organisers and analysis of the obtained computer ethics syllabi. It will attempt to answer the research question **RQ2**.*

3.1 Aims

Since most available resources and studies come from North America, it was decided to investigate which approaches to teaching ethics are most commonly used in the United Kingdom. To structure this investigation, some aims were defined:

- Conclude if a majority of students pursuing computer science degrees are exposed to some form of ethics training.
- Identify when ethics is most commonly first introduced in computer science curricula.
- Explore course organisers' views on computer ethics and its pedagogy.
- Identify approaches to teaching computer ethics most commonly used in the United Kingdom.
- Identify ethics topics most commonly covered in computer science curricula.
- Identify ways of assessing computer science students on ethics.
- Understand attitudes of students towards computer ethics.

3.2 Questionnaire

3.2.1 Participants

16 universities based in the United Kingdom were identified as participants in this study. To ensure a variety of opinions and attitudes, a mix of universities based in Scotland, Wales, South and North of England was chosen. Additionally, some of these institutions were suggested by my supervisor, who identified universities which have previously shown interest in computer ethics.

Area in the United Kingdom	University Name
Scotland	The University of Glasgow
	University of Aberdeen
	University of Dundee
	University of St Andrews
Wales	Aberystwyth University
	Cardiff University
	Swansea University
South of England	Imperial College London
	Kings College London
	University College London
	University of Bristol
	University of Cambridge
	University of Oxford
North of England	University of Manchester
	Newcastle University
	Durham University

Table 3.1: Full list of institutions which were contacted to take part in this study

For each of these institutions I followed the outlined steps to identify potential participants, i.e. staff members/course organisers with an interest in computer ethics.

First, I identified a range of computer science degrees, including fields like data science, software engineering or artificial intelligence, for each institution. Due to the nature of this investigation, I focused only on undergraduate programmes, i.e. bachelor's and integrated master's degrees.

Next, for each degree programme, I identified courses with names, learning outcomes or summaries which included keywords, such as "ethics", "society and technology", "accessibility", "human-computer interaction" and "professional issues".

Lastly, for each course, contact information for the course organiser was found and they were chosen as potential participants. For institutions where more than one course was identified, potential participants were prioritised if their course was compulsory or was specifically related to ethics in computer science. Since information on degree programmes and courses were sometimes incomplete or not up to date, a few participants were identified by my supervisor, during future interviews or through the areas of their research.

Overall, 26 potential participants were identified and contacted to take part in the study.

3.2.2 Design of the questionnaire

The questionnaire (Appendix A) was designed in Microsoft Forms and sent to the identified individuals to receive first-hand information on the content of the courses. Since information on some university websites was incomplete or not up to date, it was crucial to contact everyone personally and gain insights into how the courses they deliver fit into the degree programmes and the content of these courses.

The questions shown to the participants were determined by their previous answers in order to cover the highest range of possible responses. The survey questions covered themes such as whether the institution aims to introduce students to computer ethics, when this is done and whether the school offers a compulsory or an optional standalone course on ethics. The participants were also asked to provide an up-to-date syllabus for their course or provide a description of topics they usually cover. They were also asked to provide their contact details if they were interested in being contacted to participate in the second stage of the study (the interview).

3.2.3 Results and Discussion

Out of 26 individuals contacted to participate in the study, 10 replied to the questionnaire, giving a response rate of 38%. Each of these 10 participants represented a different higher education institution in the UK. In addition to the 10 participants who directly replied to the survey, 4 answered via email indicating that they were unfamiliar with the structure of computer science degrees at their respective institutions.

Area in the United Kingdom	Number of participating institutions
Scotland	3
Wales	1
South of England	4
North of England	2

Table 3.2: Participants by area in the UK

Answer	Count	Percentage
Yes	9	90%
No	1	10%

Table 3.3: Is computer ethics taught at your institution?

Answer	Count	Percentage
Yes	7	78%
No	2	22%

Table 3.4: Does your institution offer a dedicated standalone course on computer ethics?

Answer	Count	Percentage
Yes	5	71%
No	2	29%

Table 3.5: Is the standalone course on computer ethics compulsory?

Year	Count	Percentage
1	4	44%
2	3	33%
3+	2	22%

Table 3.6: Years in which computer ethics is first introduced to undergraduate students

In both instances when institutions do not offer a standalone course, they instead deliver a submodule which is compulsory for all computer science students. One of the respondents who offers an optional standalone course (delivered in year 3+) additionally indicated that their institution aims to introduce students to issues related to computer ethics in Year 1. How this is done was not specified by the participant.

According to these results, the majority of the students at the investigated institutions are exposed to some form of ethics training, with one institution not teaching ethics at all and one delivering an optional course only. Additionally, most institutions choose to introduce computer science students to ethics issues in the first two years of their undergraduate degrees. It is worth noting that the only respondents (2 participants) who introduce computer ethics in *Year 3+* are based in Scotland. This could be because degrees in Scotland last one year longer and a typical Scottish first-year student is usually younger compared to a first-year English or Welsh student.

3.3 Interviews

3.3.1 Participants

Out of 10 participants who responded to the survey, 5 agreed to take part in this stage of the study. To ensure anonymity, they will be addressed in this paper using identifiers presented in the table below. It is important to note that all participants deliver courses within informatics departments at their respective institutions.

Participant	Characteristic
P1	course organiser for a stand-alone optional course on ethics
P2	course organiser for a stand-alone compulsory course on ethics
P3	course organiser for a stand-alone compulsory course on ethics
P4	course organiser for a submodule on ethics
P5	course organiser for a submodule on ethics

Table 3.7: Participants for the interview stage of the study

3.3.2 The process

This stage consisted of conducting 30-45 minute interviews via Microsoft Teams[30]. Three interviews were recorded and transcribed via a built-in Teams tool, while two were recorded on an iPhone and then transcribed, due to technical difficulties. Each participant received a Participant Information Sheet and a Consent Form prior to the interview (Appendix B).

The interviews followed a semi-structured approach [31] with a set of predefined, probing and open-ended questions allowing the participants to venture in the direction they deemed relevant to the topic. Each participant was asked the same questions (Appendix C) with a few extras that were personalised depending on their answers to the survey (delivering a standalone course vs a submodule, delivering an optional vs compulsory course etc.). As per the semi-structured format, these questions were not necessarily asked in a specific order. Instead, the subsequent questions were determined by the direction of the discussion, while ensuring all predefined themes were covered. At the end of the interview, each participant was additionally asked to express any extra thoughts and themes they wanted to discuss before the end. 5 major themes which overlap with the existing research questions were covered during the interviews.

Participants' views on computer ethics: The participants were first asked to define ethics in their own words and explain how they view ethics when put into the context of computer science. They were also asked to comment on why they believe it is crucial to provide ethics training to computer science students.

Effectiveness of different approaches to teaching ethics: The participants were asked to explain which approach for delivering computer ethics they believe to be the most desirable and relate their answer to the approach they take at their institutions.

Topics covered: The participants were asked to provide some insights into the topics they cover and comment on which ethics topics they believe all computer science students should be exposed to.

Assessment: The participants were asked to explain the types of assessments they use in their courses and to comment on how students engage with assessments that are different in structure to assessments typically used in computer science courses.

Students' attitudes: The participants were asked to provide some insights into students' attitudes and comment on how students engage with content not typical for a computer science course.

3.3.3 Data Collection and Analysis

The transcripts were combined with notes I took during the interviews and the content of these was analysed using Thematic Analysis (TA), which is often used when dealing with qualitative data, e.g., interviews [32]. Initially, codes were generated using the deductive approach (closed-coding) based on the themes identified in section 3.3.2. Next, inductive analysis (open coding) was used to discover themes reflected in the data [33]. This was conducted with the use of NVivo [34], which is commonly used in qualitative research.

3.3.4 Results

3.3.4.1 Participants' views on computer ethics

Before discussing the approaches to teaching computer ethics, it is first important to understand definitions that guide participants in their courses as well as their motivations behind teaching these topics. All participants identified ethics as a way of choosing between what is right or wrong with P1 mentioning that "ethics is a framework for making decisions" and P4 defining ethics as "guidelines and processes which help us make moral decisions." P3 explained that they do not see the definition of ethics changing when put into the context of computer science with P2 mentioning a book by Stephanie Hare [35] who explains "how ethics for computer scientists is not something that's like a tick-box exercise." [P2] P5 suggested that ethics also has a personal component of "how we develop our own sense of right and wrong." During the interviews, all participants emphasised the necessity of teaching computer ethics with P1 expressing their disappointment over their course being optional and delivered later in the curriculum. They also expressed that not delivering ethics topics earlier in the degree means that students who choose computer science courses as electives are never exposed to computer ethics (especially in the context of the Scottish system which is more flexible compared to England and Wales [36]). With the current growth of cases and examples of unethical use of technology [37], the participants find it crucial to deliver ethics topics to computer science students, with some believing that it is not enough to outsource the issue to be dealt with by companies and employers. P1 does not believe that companies would ever ask and require their employees to be trained in ethics "because of all this ethics washing" with P2 stating that ethics is "something that everyone who's designing, developing, evaluating [...] new technologies needs to consider all the way through the process." Additionally, P5 suggested that to have a successful collaboration between ethicists and computer scientists, both fields need to find a common language, which can be achieved if computer scientists have a "base, fundamental, foundational understanding of the other (ethics)." [P5] The participants also discussed how oftentimes these unethical uses of technologies are not done with malicious intent, but rather due to lack of consideration, thus emphasising the idea of bringing awareness to said issues within computer science degrees.

3.3.4.2 Effectiveness of different approaches

This section was grouped into themes that emerged when conducting TA.

Accreditation: One of the emerging themes was accreditation, which was also mentioned in section 2.3.2. P3 explained that the choice to deliver a standalone compulsory course was made to satisfy the BCS accreditation requirements. They also expressed that accreditation played a key role when developing the course (not originally developed by P3) and choosing the topics. According to P1, most universities in the UK do not try to obtain any sort of accreditation, thus it is really difficult to get things mandated when it comes to curricula. They also expressed that the BCS ethics is very constrained and includes a small variety of topics.

Embedded ethics: All participants expressed their support towards the embedded ethics approach, with P1 and P5 mentioning that they have been trying to suggest this approach to their respective departments. P3 mentioned that despite their positive attitude towards their standalone compulsory course, it is not enough, since ”these are concepts that they (students) need to be given repetitively”. P2 and P5 also emphasized that despite their support for embedded ethics, they believe that universities should first introduce students to these topics in a core course to allow them to dig deeper ”and then reinforce the idea throughout their degrees” [P2]. P1 also suggested that since the Scottish system is not dissimilar from the US, the approaches discussed in section 2.4 could be more easily applied in Scotland.

Challenges with embedded ethics: As expected, there are some challenges and issues that prevent the participants from introducing the embedded ethics approach at their institutions (section 2.4). Firstly, both P1 and P2 mentioned that computer science degrees are already overloaded and introducing additional ethics activities could lead to too much workload for their students. This issue was partially addressed by the embedded ethics team at the University of Toronto St.George who found that even a small amount of ethics content spread evenly throughout the degree can increase students' interest in ethics and improve their sense of self-efficacy [38]. P2 also mentioned that at their institution ”faculty are kind of autonomous”, thus no course organiser can be forced to include ethics in their course. According to P2 and P5, some faculty members struggle to see how ethics is related to computer science and ”wouldn't feel comfortable broaching that material in their own modules (courses).” [P5] Additionally, participants faced some issues with cross-disciplinary teaching. Both P1 and P5 attempted to establish a collaboration with the philosophy departments at their respective institutions and were unable to find philosophers interested in such collaboration. P5 acknowledged that this could be due to the way ”that the universities are [...] built that [...] prevents interdisciplinary teaching, co-teaching.”

Departmental curriculum awareness gap: When asked to provide some insights into other courses at their institutions that mention ethics in their curricula, all participants were unsure of the answer. This further shows that most faculty members are not familiar with the content of other courses taught at their institutions. Additionally, P5 mentioned that they believe that, contrary to the US (section 2.4.1), there is a lack of computer ethics resources and curricula being shared across institutions in the UK.

The tool that was further developed as part of this project attempts to address some of the issues introduced above, especially the issue of lack of co-teaching within departments and beyond.

3.3.4.3 Topics covered

All participants emphasized the importance of showing students how ethics is applied in the realm of computer science and discussing ethical challenges they might face in their future careers. Both P1 and P2 teach students law alongside ethics since ”law is slightly more practical.” [P1] P3 and P4 also mentioned covering law-related concepts in their curricula, such as GDPR and intellectual property. Despite most participants mentioning the importance of introducing some existing ethical frameworks,

P4 suggested that although they find philosophy to be ”fascinating a lot of computer science undergraduates don’t.” Specific topics mentioned by participants during the interviews will be included in the results presented in section 3.4.

3.3.4.4 Assessment

Participants use different approaches when assessing students such as exams, presentations, essays, and reports. P4 explained that since their ethics submodule is part of a year-long group project, they assess students based on reflective reports to take the pressure off the final work they need to produce. All participants mentioned that students find this type of material challenging with P3 stating ”they really struggle with more the humanity side of things compared to the technical stuff.” All participants believe it is a general issue that computer science students face. Despite including writing assignments throughout the degree, students still find it challenging with P1 stating ”I don’t feel that in fourth or fifth year, I should be teaching people how to write essays.” P3 mentioned that throughout the years they had to adjust the literature review report to make the criteria more structured and the topics less open-ended due to the students’ negative feedback.

3.3.4.5 Students’ attitudes

All participants expressed that they see computer science students struggling with issues which do not have a right or wrong answer. P5 expressed that a lot of the students are anxious about a course which is different to what they usually encounter. Students are also surprised by the complexity of the issues they are presented with. P2 mentioned that they sometimes find it challenging ”to get that ambiguity across to people who very much think in binary.” Participants also expressed that they feel that students are not very well prepared to take these courses with P4 saying that ”it’s hard for 18-year-olds to imagine themselves in these situations (facing ethical issues at work).” However, the participants believe it is not necessarily a bad thing. Both P1 and P3 expressed that they start their courses ”from scratch” [P1] to first equip students with the necessary skills. P1 also mentioned that a lot of students struggle with reading papers that are not tech-related saying that ”we talk about interdisciplinarity a lot, but we don’t actually equip people with the skills for it.” Despite all participants mentioning that they usually have a few students who do not find the course useful, most seem engaged with the content. For instance, P1 mentioned that the optional course they deliver had to be capped due to high enrollment.

3.4 Curriculum analysis

3.4.1 Data collection and Analysis

9 curricula were obtained through the questionnaire discussed in section 3.2 and 7 were included in this study due to incomplete information. Topics mentioned by the course organisers during the interviews were combined with their curricula. Following methods used by Fiesler in their syllabi analysis [39], each syllabus was first mined for

topics listed in a schedule or a reading list. Affinity diagramming was used to create a codebook of higher-level topics presented in table 3.8 before formally coding all the topics in each class [40]. The coding process was again conducted with NVivo [34]. Due to the small sample, topics with only one course covering them were also included in the results.

3.4.2 Results

Topic	Courses
Privacy & Surveillance	7
Philosophy	6
Professional Ethics	6
Algorithmic Bias & Fairness	5
Law & policy	5
Codes of conduct	4
Accountability	3
Censorship	2
Economics	2
Impact of AI	2
Research Ethics	2
Cybersecurity	1
Environmental impacts	1
Ethics washing	1
Lethal Autonomous Weapons	1
Medicine	1

Table 3.8: Identified topics with number of courses that cover them

3.5 Limitations and Further Work

There are some limitations to the work which are important to discuss. Firstly, due to the busy schedules of participants, only a portion of them were able to reply to the survey and schedule an interview, thus resulting in a small sample that was investigated. Since the investigation only included professors who are already interested in computer ethics, it would be valuable to extend the study and choose a sample of participants with more varied opinions on computer ethics education. Additionally, information on students' attitudes towards ethics was provided from the perspective of course organisers only. It would be worth surveying and speaking to the students at the university to understand how they view computer ethics and whether they find this content useful. Since coding performed during curriculum analysis was done by one person, the inclusion of some topics in the categories presented in table 3.8 was subjective. Results obtained from this study were further used to guide the development of the tool.

Chapter 4

Requirements gathering and design

*This chapter describes the motivation behind the development of the tool and the process of gathering its requirements. Additionally, it provides insights into design choices that were made during the development. It aims to answer **RQ4**.*

4.1 Motivation

During the interview stage described in section 3.3, I identified numerous challenges professors face when advocating for the inclusion of ethics in computer science curricula. Despite the participants supporting the idea of delivering these topics throughout the degree, most institutions choose not to employ this approach for various reasons explained in section 3.3.4.2. To address some of these issues and encourage the integration of a higher number of ethics topics in computer science curricula, I decided to develop a curriculum mapping tool, which would provide insights into what ethics topics are covered at a given institution. It will also attempt to enable course organisers to share more resources on computer ethics.

4.2 Requirements

The requirements were gathered based on the challenges professors face when attempting to integrate computer ethics throughout the degree, which were identified during the interview stage of the study. The developed tool will attempt to address a few of these challenges: (CH1) some faculty members do not feel confident in delivering ethics topics, (CH2) lack of co- and inter-disciplinary teaching, (CH3) some students find it difficult to engage with computer ethics content, (CH4) lack of knowledge of what is being taught for different degrees within the department.

Additionally, tools containing resources on computer ethics mentioned in section 2.4.1 were analysed and compared to obtain key features available in similar tools. (AT1) each activity has multiple tags which identify ethics topics covered by this activity, (AT2) there is an option to filter activities by ethics topics, (AT3) there is a list of activities

delivered at the institution, (AT4) there is information on which activities are covered by which courses.

To ensure that the design was user-friendly, the 10 Nielsen Heuristics were considered during the process of identifying the requirements. These are included in Appendix D and throughout the work will be referred to as N1...10 [2].

No	Requirement	Reasoning
1	The tool should display a form for proposing new activities, which should display clear error messages if filled incorrectly	CH2, CH3, N5, N9
2	The system should have a navigation bar to allow users to seamlessly move through different pages	N1, N3, N6
3	The tool should display information on available activities and courses which include them	CH1, CH2, CH4, AT3, AT4, N2
4	Each activity should be clearly tagged with associated ethics topics	AT1, N2, N4
5	The user should have the option to contact a person who proposed each activity	CH1, CH2
6	The tool should allow users to filter activities by ethics topics, and courses by year of delivery	AT1, AT2, N7
7	The tool should display information on courses currently available at the university and degrees for which these courses are optional/compulsory	CH4, AT4, N2
8	The tool should display a curriculum map visualisation for each degree	CH2, CH4, Literature Review, N7
9	Information displayed in the curriculum maps should clearly match the structure of degrees available at the University	CH2, CH4, N2
10	Curriculum maps and their summaries should include an exhaustive list of ethics topics commonly covered in a computer science curriculum	Curriculum analysis
11	The tool should provide a summary of results for each degree which identifies gaps and redundancies in the curricula	CH2, CH4
12	The tool should have a minimalist design with clear icons and descriptions where needed	N8

Table 4.1: Initial User Interface Requirements

Chapter 5

Low-fidelity prototype

*This chapter provides insights into the design of the low-fidelity prototype. The prototype was further evaluated by 5 experts in HCI to inform the design of the tool and apply changes to the requirements before the development of the high-fidelity prototype. This chapter will attempt to answer **RQ3** and **RQ4**.*

5.1 System Design

Based on the requirements described in Chapter 4 a low-fidelity prototype was designed in Figma [12]. Figma was chosen as it allows to clearly mimic the future flow of the final product, thus making it easier to spot any potential usability issues during the evaluation. The identified issues can be further addressed during the high-fidelity prototype implementation. It should be noted that in the design, activities are referred to as modules since the phrasing was changed after the low-fidelity prototype evaluation. For consistency, the term activities will still be used throughout this chapter. Due to time constraints the study outlined in section 3.4 was conducted in parallel with designing the low-fidelity prototype, thus placeholder ethics topics were chosen to be included in the design (Requirement 10). Screenshots representing the design of the low-fidelity prototype are available in Appendix E

Login page: When the user first enters the app they are prompted with a welcome page, which allows them to either enter a form for proposing new activities (Requirement 1) or log into the system. The authentication would be done through EASE to ensure that the tool matches the systems usually used at the university (N2, N4). For logged-in users a navigation bar enables them to move through the pages (Requirement 2). Users are not required to log in to submit a proposal to allow contributions from outside of the university.

Proposing activities: This page allows the users to fill in a form and send a proposal for a new activity. The user is asked to provide an activity name, and description and choose the ethics topics covered by this activity from a drop-down. Additionally, they are asked to provide their name, surname and email address (Requirement 1).

Activities: The users can view all activities currently available at the university as a list of minimalist cards with some essential information on each activity (Requirement 4). The users are allowed to filter activities by ethics tags (Requirement 6). Clicking on each card takes a user to a page with extra information on who added the activity and which courses deliver its content (Requirements 3, 5).

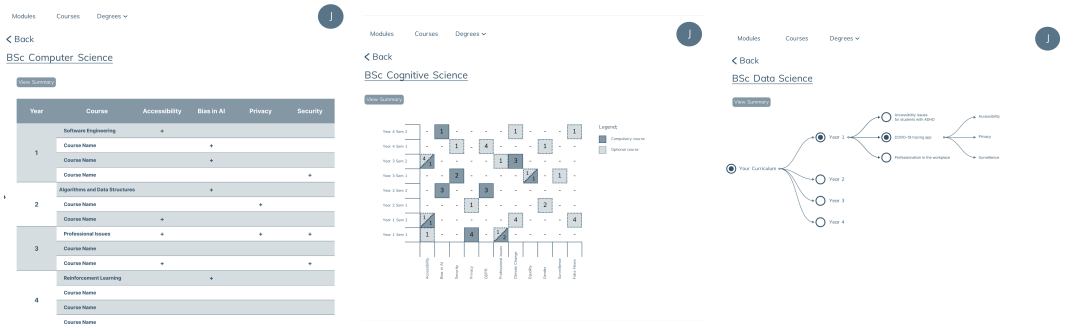
Courses: The users can view a list of cards with essential information on different courses delivered at the university (Requirement 7). The page also includes a filter option to filter courses by year of delivery (Requirement 6). Clicking on each card takes the user to a separate page which provides more information on degrees for which this course is optional/compulsory (Requirement 7). The page also displays all activities delivered on this course (Requirement 3).

Curriculum maps: The degree page displays a curriculum map for the chosen degree. In the LFP, 3 different visualisations were designed, each following a different methodology (Requirements 8, 10). For each map, feedback from experts and users was further obtained to choose a visualisation that was easiest to understand and interpret.

1. Table view: Design for the table view can be seen in Figure 5.1a, which was created based on steps for designing curriculum maps outlined in a guide from the University of Northern Colorado [41]: (1) The programme learning outcomes were identified as ethics topics commonly delivered to computer science students, (2) Courses available for each degree were placed as rows in the table. To provide crucial information on the structure of the degree programme, after clicking on the name of each course, a pop-up with a link to the chosen course and information on whether it is optional or compulsory for this degree is shown. (3) A ”+” symbol was placed in cells to indicate which courses support the identified learning outcomes. To identify when these topics are delivered throughout the degree, courses were grouped into years of delivery.

2. Heat map: Design for the heat map view can be seen in Figure 5.1b, which was created following the methodology used at the University of Glasgow to visualise ”where and what pathology is covered across Phases 1, 2 and 3 of the Glasgow MBChB curriculum” [42]. Each cell in the grid was filled with a number related to courses delivered in a specific year and semester (rows), covering a specific ethics topic (columns). Depending on the structure of the degree programme a chosen shading and border were applied to identify cells containing a number related to compulsory (solid) and optional (dashed) courses. Cells which included both optional and compulsory courses were diagonally split in half. Clicking on the number in a chosen cell displays a pop-up with names and links to courses included in that cell.

3. Curriculum tree: The third and final visualisation can be seen in Figure 5.1c, which was designed based on the ”Explore view” feature in the Sofia curriculum mapping tool for medical schools [43]. This view applies a tree-like structure to visualise a curriculum for each degree programme. First, the curriculum is split into years, next each year is split into activities and each activity is split into ethics topics it covers. To ensure that the view was not too crowded, it was decided not to include courses in it. Instead, the user can click on the activity name which would take them to a page with information on which courses deliver it.



(a) Table View (b) Heat Map (c) Curriculum Tree

Figure 5.1: Curriculum maps designed for the low-fidelity prototype

Summary of results page: When a user clicks the *View Summary* button, they are taken to a page which identifies potential gaps and redundancies in the curriculum for the chosen degree. It shows ethics tags for topics, which are *missing from the degree*, *covered by optional courses only*, *covered by at least one compulsory course*, and *covered by more than one compulsory course* (Requirement 10, 11).

5.2 Cognitive Walkthrough

As the first stage of the low-fidelity prototype evaluation, a cognitive walkthrough was conducted with the help of two former HCI students. It is important to note that this was carried out on a slightly different version of the previously shown design. Some usability issues identified during this walkthrough were fixed before the evaluation with experts. Not all issues were immediately addressed due to little time between the two stages.

5.2.1 Aims

- Evaluate the learnability and intuitiveness of the tool
- Identify any usability issues

5.2.2 Participants

The participants were chosen based on their enrollment in the HCI course. Additionally, the participants had previous applicable experience: one working as a full-stack Software Engineer and the other as an accessibility auditor for government websites.

Identifier	Characteristic
P1	4th Year Artificial Intelligence and Computer Science student with experience in HCI and accessibility
P2	5th Year MInf student with experience in Software Engineering and HCI

Table 5.1: Participants for the cognitive walkthrough

5.2.3 The process

All participants were given the Participant Information Sheet and Consent Form (Appendix F) before the start of the meeting. This stage consisted of a 30-minute in-person session with both participants. Due to the small number of participants, I was the facilitator and the recorder while P1 and P2 were the evaluators. During the session, the evaluators tried to accomplish 4 different tasks from the perspective of a new user. Each task was broken down into steps, which were established prior to the session, that the user needed to follow. At each step, the facilitator asked the evaluators these four questions: (1) Will users try to achieve the right result? (2) Will users notice that the correct action is available? (3) Will users associate the correct action with the result they're trying to achieve? (4) After the action is performed, will users see that progress is made toward the goal? [44] Whenever the answer was different than *Yes* the facilitator asked the evaluators to explain what a new user could struggle with.

5.2.4 Data Collection and Analysis

During the session, the recorder took notes for each task, step and question. These can be found in Appendix G.1. The notes were further analysed to find tasks and steps new users were likely to struggle with to identify any parts of the design that would have to be amended for the high-fidelity prototype.

5.2.5 Results

Task 1: Propose a new activity on *Privacy* and *Security*

The evaluators immediately noted that the link to the form was not instantly noticeable with P1 mentioning that new users might "try to log in straight away". The participants had no issues filling out the form and identifying the drop-down as a multi-selector. Both evaluators mentioned that a pop-up confirming the successful submission of a new activity proposal should be shown to the user to indicate progress.

Task 2: Find a course with an activity on *Accessibility* delivered in Year 1 of BSc Computer Science and check if it is compulsory for this degree

The evaluators had no issues identifying the appropriate link on the navigation bar and confirmed that a new user would not struggle with identifying the correct degree page. P1 mentioned that even though they did not struggle to find the correct course name (Software Engineering), the lack of borders in the table might make analysis more challenging for people with learning difficulties. Both of the evaluators mentioned that the fact that the course name was clickable was not obvious and required a lot of cognitive effort. P2 suggested that it should be "immediately visible which courses are optional or compulsory" and clicking on the course name would take the user straight to the associated course page.

Task 3: Find names of courses delivered in Year 1 Semester 2 on *Accessibility* for BSc Cognitive Science

Similar to the previous task the evaluators had no issue accessing the degree page

through the navigation bar. However, they again noted that a new user might struggle to ”realise that the cells can be clicked.” [P2] They also noted that it was not obvious that the user could hover over the names of the courses in the pop-up to see which are compulsory/optional. It was again suggested to immediately show the user which numbers are associated with compulsory and which with optional courses. At this stage, the evaluators also suggested adding short instructions for the curriculum maps.

Task 4: Find all ethics topics delivered during the COVID-19 tracing app activity in Year 1 of BSc Data Science

Again, the evaluators did not struggle when interacting with the navigation bar. They both noted that a new user might not notice the *Your curriculum* radio button with P1 mentioning that radio buttons should always have ”more than one option.” Both evaluators mentioned that as more activities get added to the tool, this view could become very cluttered making it difficult to interpret.

Usability and accessibility issues addressed before the evaluation with experts: green and red colours are confusing for distinguishing between optional/compulsory courses since they indicate something is right/wrong (P1, P2 - changed to light blue and dark blue), for accessibility reasons colour is not a good discriminator (P1 - dashed/solid borders were added).

5.3 Evaluation with Experts

The second stage of the evaluation of the low-fidelity prototype was done with the help of course organisers at the university who were identified as future end-users for the tool and experts in HCI and education.

5.3.1 Aims

- Determine any potential usability issues within the prototype
- Identify which curriculum map visualisation (Figure 5.1) users find easiest to interact with
- Gather feedback on what should be included in the summary of results
- Gather feedback on any improvements and new features the users would like to see

5.3.2 Participants

The participants for this study were also chosen due to their expertise in HCI and education. They could spot any usability issues with the design and provide insightful feedback for new features and improvements. To ensure anonymity all participants will be referred to using identifiers shown in the table.

Participant	Characteristic
E1	Expert in Education and Data Science
E2	Expert in HCI and Digital Accessibility
E3	Expert in HCI, Software Engineering and Education

Table 5.2: Experts for the low-fidelity prototype evaluation

5.3.3 The process

This stage of the low-fidelity prototype evaluation consisted of conducting 30-minute individual, in-person meetings with the participants. Each meeting was recorded on an iPhone and further transcribed. Prior to the meeting, all participants received a Participant Information Sheet and a Consent Form (Appendix F).

At the beginning of each meeting, a short demo was given to the participants and they were asked to familiarise themselves with the tool. All meetings followed the think-aloud method, which is often used when conducting usability studies [45]. Before the start of the think-aloud session, the participants were asked to talk through all the decisions they made when interacting with the tool. The participants were given a set of tasks and asked to ”keep talking” while performing them. After completing the tasks, a short semi-structured interview [31] was conducted to gather participants' opinions on the available curriculum maps, the summary of the results page, the usefulness of the tool and any additional features they would like to see in the future. Tasks for the think-aloud session and interview questions can be found in Appendix G.2.

5.3.4 Data Collection and Analysis

To understand the data and identify any themes commonly mentioned by the participants, Thematic Analysis [32] was used to analyse the data. To ensure there was no predefined bias, the inductive (open-coding) approach was applied [46]. This analysis was again conducted using the NVivo tool [34].

5.3.5 Results

Curriculum maps: Both E1 and E3 did not find the curriculum tree particularly useful with E3 stating that it ”doesn't give me the whole picture at once. I need to navigate through it.” Both participants thought that the heat map was particularly useful. E1 also suggested that the table view was beneficial mentioning that ”the two views [...] are complementary.” Contrary to the other participants E2 found the heat map and the table view confusing and thought that the curriculum tree was clearer. These differing opinions show that different users find it easier to interact with different visualisations. This was also confirmed by E1 and E3 who suggested including both the heat map and the table view in the final implementation with E3 mentioning that ”there are people who prefer tables and people who prefer more visual stuff.” Participants also had some suggestions on how to improve the visualisations with E1 mentioning grouping the courses by semesters as well as years in the table view. E3 also suggested using a level of opacity as a way to clearly distinguish between cells with different numbers. E1

expressed their concern over the scalability of the table view stating that it would get ”unmanageable when you have a large number of courses.” This issue was also raised by my supervisor when considering the number of ethics topics in both the table view and the heat map.

Summary of results page: All participants found this page particularly useful with E3 mentioning that ”it highlights where courses would need to cover more of these (ethics topics)”. E1 suggested that the feature accomplishes the same task that the user is trying to achieve when analysing the curriculum maps, thus making it particularly helpful. Participants also mentioned that they were confused with the naming for the *View Summary* button, with E3 suggesting that they would like it ”addressed as recommendations”. E1 and E2 also suggested including the number of courses next to each ethics tag in sections *covered by optional courses only* and *covered by at least one compulsory course* for each degree. Clicking this number would then display all courses associated with this tag. E2 mentioned that with this feature, the *covered by more than one compulsory course* section would not be necessary, which would ”make the screen clearer.” E3 also suggested splitting the analysis by semesters since ”we shouldn’t have too much of it (ethics) in a single semester and nothing in the other.”

Usability issues: The participants also helped to identify some usability issues and these are listed here: filters are not the same for the *All Courses* and *All modules* pages (E2), the current state is not underlined in the navigation bar (E2), titles should not be underlined (E1), links are not underlined so it is unclear what is clickable (E1, E2, E3), use of pop-ups, borders and colours to distinguish compulsory and optional courses in the heat map and the table view is not clear (E1, E2, E3), use of ”+” symbol in the table view suggests it can be clicked and incremented (E3), the term *module* can be easily confused with the term *course* (E1, E2, E3).

Suggestions for improvements: The participants also had some useful suggestions for how to improve the existing system. E2 suggested that the users should also be able to propose new ethics topics since ”things evolve, and you may have a topic which is not covered.” E3 also mentioned that the tool could include a summary of ”recent research and literature on gaps in teaching ethics” to spread awareness on the importance of delivering computer ethics.

5.4 Revised Design

The results obtained in the low-fidelity prototype evaluation were used to apply any changes to the existing requirements and identify new requirements for the tool. Each suggestion was assessed in terms of the severity of impact on design to decide which recommendations would be further implemented for the high-fidelity prototype. Due to the severity of the usability issues described in section 5.3.5, all were addressed for the high-fidelity prototype implementation. Due to time constraints filtering by ethics topics on activities and courses pages was left as future work and replaced by a search-by-name option. The implementation of the table view and the heat map was prioritised for the high-fidelity prototype. These visualisation were chosen due to the complexity of the curriculum tree and mixed feedback received from the participants.

No	Recommendation	Addressed	Reasoning
1	Underline current state in the navigation bar	Yes	N1, E2
2	Underline all links	Yes	N6, P1, P2, E1, E2, E3
3	Use "*" symbol to distinguish compulsory and optional courses	Yes	N8, E1, E2, E3
4	Use *check* symbol in the table view	Yes	N8, E3
5	Change the term *Module* to *Activity*	Yes	N2, E1, E2, E3
6	Support searching by name on *All courses* and *All Activities* pages	Yes	N7
7	Rename the *View Summary* button to *Topic Recommendations*	Yes	N2, E3
8	Offer 3 complementary visualisations for curriculum maps	Partially	N7, E1, E2, E3
9	Group courses in the table view by years and semesters	Yes	E1
10	Apply different levels of opacity to cells with different numbers in the heat map	Yes	N8, N6, E3
11	Support filtering by compulsory courses on table view	Yes	E1, Scalability
12	Include a clickable number of courses associated with ethics tags in the *Topic Recommendations* page	Yes	N8, E1, E2
13	Support proposing new ethics topics	Yes	E2
14	Support filtering the table view and heat map by ethics topics	Yes	Scalability
15	Add borders to the table in the table view	Yes	P1, P2, N8
16	Include short descriptions for each curriculum map	Yes	P1, P2, N10
17	Show a pop-up on successful activity proposal submission	Yes	P1, P2, N1
18	Split the *Topic Recommendations* by semesters	Future Work	E3
19	Support filtering by ethics topics on *All courses* and *All Activities* pages	Future Work	E2, N7
20	Include extra resources and research papers on computer ethics	Future Work	E3

Table 5.3: Recommendations from the participants

Chapter 6

High-fidelity prototype

*This chapter provides insights into the design of the high-fidelity prototype, which was further evaluated by 3 HCI experts. An SUS survey was also conducted to establish if the tool is viable in terms of usability. This chapter will attempt to answer **RQ3** and **RQ5**.*

6.1 Development tools

These are the tools that were used during the development of the high-fidelity prototype.

ReactJs is a JavaScript library which is often used in web and app development [47]. Since it is component-based, it allows the developer to create reusable pieces, which are further applied to create complex UI designs. Due to my previous experience with this framework, it was chosen for this project.

React Bootstrap is a popular front-end framework which provides already designed React components [48]. These are also responsive, thus the tool could be further developed with mobiles and tablets in mind. Additionally, the components are already designed with accessibility in mind.

Firestore Database and Firebase Hosting: Cloud Firestore is a cloud-based NoSQL database, which can be easily integrated with React, thus it was chosen for this project. The database was seeded with a selection of degrees and courses available at The University of Edinburgh (Requirement 9), ethics topics established in section 3.4 (Requirement 10) and activities found in resources described in section 2.4.1. To allow for the final evaluation to be partially conducted online, the tool was hosted using Firebase. The code was pushed to a GitHub repository, which was private to ensure no unauthorised access.

6.2 System Design

Taking into account the previously gathered requirements and suggestions obtained through the low-fidelity prototype evaluations, a high-fidelity prototype was imple-

mented using React. In the current version of the prototype, the tool allows the users to propose new activities and ethics topics, view all currently available activities and courses, analyse two complementary curriculum maps and obtain recommendations for existing curriculum gaps and redundancies. More screenshots of the design are included in the Appendix H. The application is live at: `https://ethics-9945b.web.app/`.

Login page: Upon entering the tool, the user can either log into the system through EASE or choose to propose a new activity or a new ethics topic (Figure 6.1). Users who do not have an EASE account are informed that they are still allowed to make proposals.

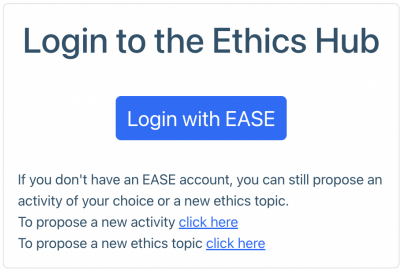
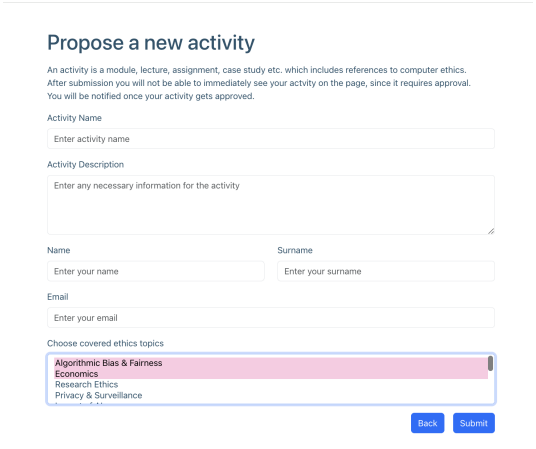
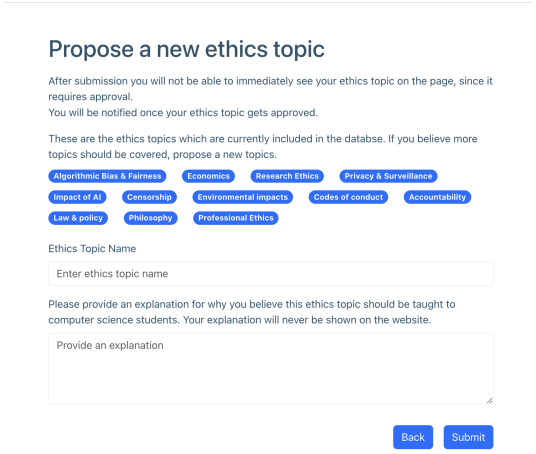


Figure 6.1: Login Page

Proposing activities and ethics topics: After choosing an option to propose a new activity or a new ethics topic (Requirement 1, Recommendation 13), the user is asked to fill out a form (Figure 6.2a and 6.2b respectively). Each field in the form is required and any mistakes are captured during submission and alerted to the user. To ensure no duplicate submissions for ethics topics are made, all topics currently included in the database are clearly stated in the form. After successful submission, a pop-up is shown to a user, who can either go back to the login page or submit another proposal (Recommendation 17).



(a) Form for proposing a new activity

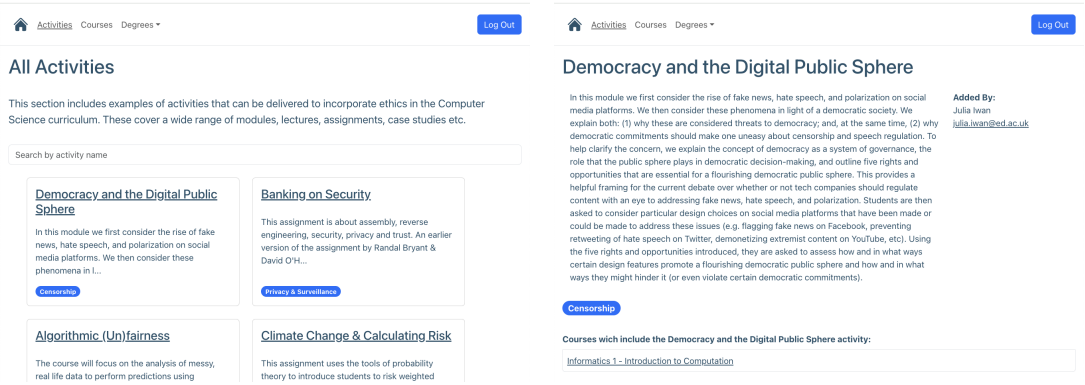


(b) Form for proposing a new ethics topic

Figure 6.2: Forms for submitting proposals

Activities: When a user clicks the *Activities* link on the navigation bar (Requirement 2),

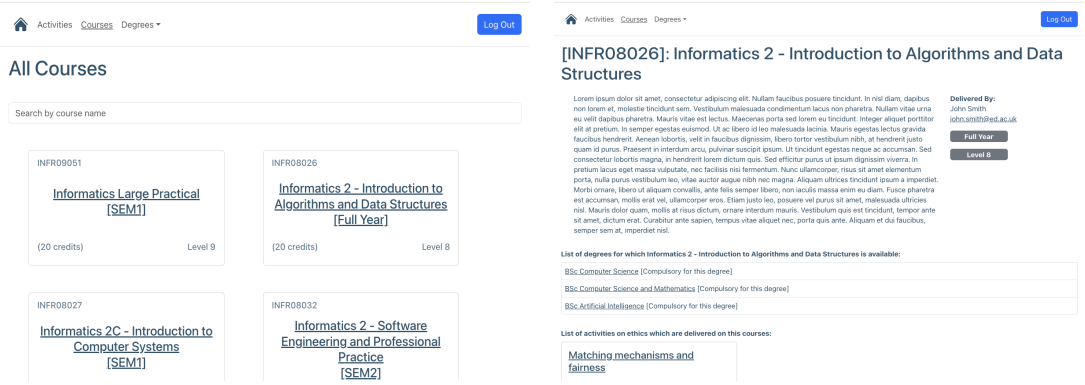
they are taken to the *All Activities* page (Figure 6.3a) which displays a list of activities currently available at the university (Requirements 3). Each card displays essential information on an activity with tags representing ethics topics it covers (Requirements 3, 4). The user is allowed to search for an activity by name (Recommendation 6). After choosing a card, the user is taken to a page which includes extra details, as well as a list of courses covering this activity (Figure 6.3b, Requirement 3).



(a) All activities page (b) Example of an activity page

Figure 6.3: Activities pages

Courses: After choosing the *Courses* link on the navigation bar (Requirement 2), the user is taken to the *All Courses* page (Figure 6.4a), which displays a list of courses delivered at the university (Requirement 7). The user is allowed to search courses by their names (Recommendation 6). After choosing a course they are interested in, the user can see extra information with a list of degrees for which this course is optional/compulsory and a list of activities delivered by this course (Figure 6.4b).

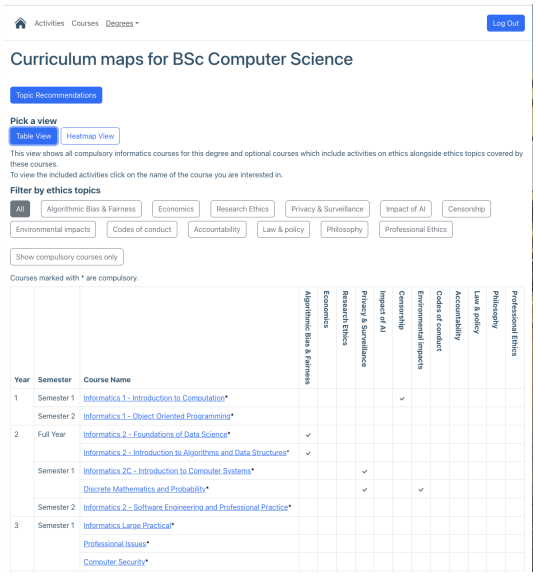


(a) All courses page (b) Example of a course page

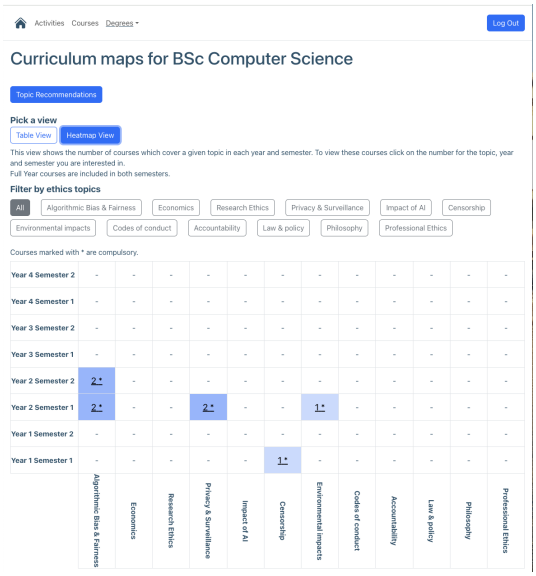
Figure 6.4: Courses pages

Degree Page: After choosing a *Degree* from the drop-down on the navigation bar (Requirement 2), the user is taken to the *Degree* page. This page allows the user to view two curriculum maps (Recommendation 8) for the chosen degree; a heat map (Figure 6.5b) and a table view (Figure 6.5a). For scalability, both views allow the user to choose the ethics topics they wish to be displayed (Recommendation 14). Additionally,

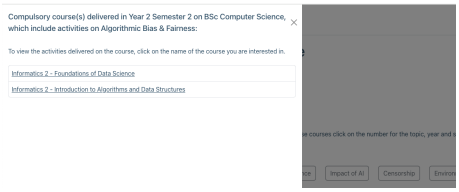
the table view enables the user to view only compulsory courses (Recommendation 11). When clicking the numbers in the heat map, an overlay showing a list of courses belonging to the chosen cell is shown (Figure 6.5c).



(a) Table view



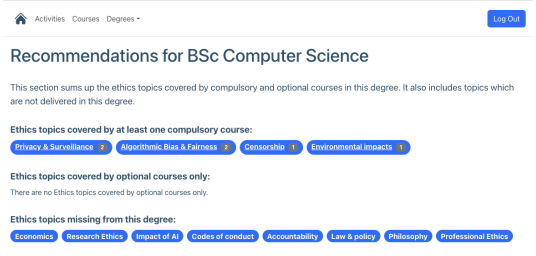
(b) Heat map



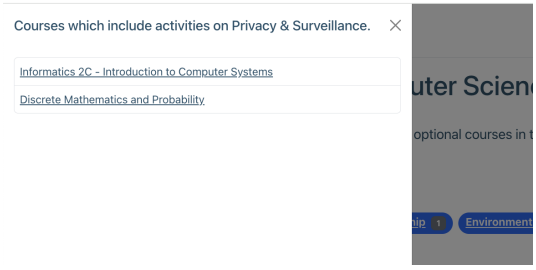
(c) Example of an overlay shown after pressing a number in a heat map cell

Figure 6.5: Degree page for BSc Computer Science

Topic Recommendations: When pressing the *Topic Recommendations* button on the *Degree* page, the user is shown a summary which identifies potential gaps and redundancies in the curriculum (Figure 6.6a). In sections *covered by at least one compulsory course* and *covered by optional courses only*, the user can see a specific number of courses which cover each ethics topic. Clicking each ethics tag will display an overlay with a list of these courses as shown in Figure 6.6b.



(a) Topic recommendations page



(b) Overlay for Privacy & Surveillance

Figure 6.6: Topic recommendations page for BSc Computer Science

6.3 Final Evaluation with Experts

This evaluation was conducted to understand the effectiveness of the tool in informing course organisers on the structure of the degree programmes available at the university when it comes to delivering computer ethics. For this reason, 3 experts in HCI and education who are also course organisers at the university were asked to participate.

6.3.1 Aims

- Determine if the tool is useful for course organisers and programme designers
- Determine the appropriateness of information displayed in the curriculum maps
- Determine how easy it is for users to interact with the tool
- Identify any usability issues and gather ideas for improvement

6.3.2 Participants

The participants who took part in this stage of the evaluation were the same experts who participated in the low-fidelity prototype evaluation. They were chosen due to their expertise and familiarity with the tool which allowed them to provide feedback on how the tool changed in comparison to the low-fidelity prototype design. To ensure anonymity all participants will be referred to using identifiers already provided in Table 5.2.

6.3.3 The process

This study was conducted in the form of individual 30-minute meetings, out of which two were held in person and one through Microsoft Teams [30]. Each in-person meeting was recorded on an iPhone and further transcribed. The online meeting was transcribed using the built-in Teams tool. All participants were given a Participant Information Sheet and Consent Form before the meeting (Appendix F). E3 who participated in the study online was additionally sent a link to the hosted tool.

At the beginning of each meeting, a short demo was given to the participants to let them familiarise themselves with the new version of the tool. Similarly to the low-fidelity prototype evaluation, each meeting followed the think-aloud method [45]. Each participant was given 8 tasks to perform and asked to talk while interacting with the app and describe any choices they were making for each task and step.

At the end of the session, the participants were also asked to rate the tool in four different categories on a scale from 1-5, with 1 being the lowest and 5 being the highest score. They were also asked to talk more about the feature which they liked the most and found the most useful and provide some suggestions for how the tool could be improved in the future. Tasks for the think-aloud session and questions asked at the end of the session can be found in Appendix J.1.

After each meeting, all participants were emailed the System Usability Scale questionnaire and asked to fill it out in their free time. Results for the questionnaire will be described in section 6.4.5.

6.3.4 Data Collection and Analysis

Similarly to the low-fidelity prototype evaluation, the transcripts were analysed using Thematic Analysis [32]. Inductive analysis (open coding) was performed to find themes reflected in the data [46]. The analysis was again performed with the help of NVivo [34].

6.3.5 Results

All participants enjoyed interacting with the tool and liked the numerous features included in it. This can be confirmed by the ratings they gave in the four categories described above. The ratings are shown in Figure 6.7

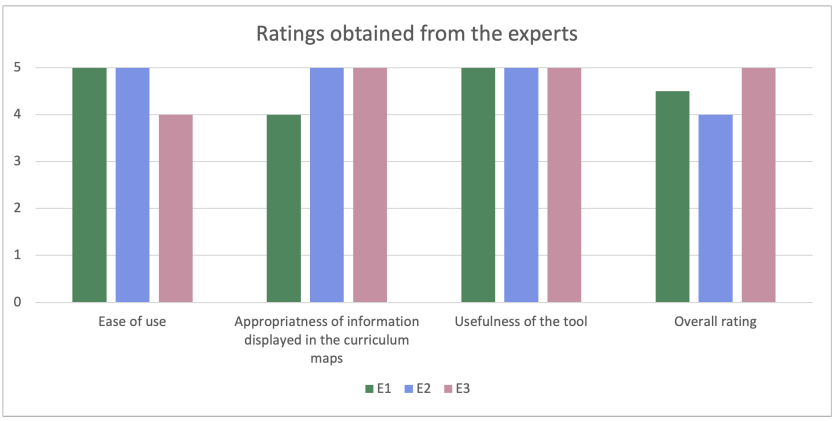


Figure 6.7: Expert ratings

Curriculum maps: All participants enjoyed interacting with the maps and, contrary to the low-fidelity prototype evaluation, did not have any issues interpreting them and performing the provided tasks. E2 who previously found both the table view and the heat map confusing, identified the heat map as their favourite feature in the tool and commented that ”it’s quite clear now.” E3 also mentioned that they ”don’t see any problems with it” when asked about the appropriateness of information displayed in the maps. The participants were able to correctly interact with the filters added for scalability reasons. However, both E1 and E2 expressed their worry over what the visuals would look like once more topics and courses get added to the tool with E1 stating ”I’m not sure how these things would scale if we have more and more topics.” E2 suggested that despite the table view being ”clear”, they wished that only the courses which cover the chosen topics would be kept in the filtered view. E2 commented that they ”don’t want to browse all the list of courses and have a tick there (top of the page) and tick there (bottom of the page).” When it comes to the appropriateness of information displayed in the curriculum maps the participants gave an average rating of 4.67/5.

Usefulness: All participants agreed that the tool was useful to them as potential end-users. E3 suggested that they particularly liked the *Topic Recommendations* page and stated that they ”think that’s a very nice thing to have because it can help with discussions in boards of studies as to what is missing from the curriculum for a certain year.” Both E1 and E2 also mentioned that they thought the curriculum maps to be particularly useful with E2 stating that the heat map gave them ”a clear idea about different topics and when they are.” E1 also commented that having a resource with some suggestions for available activities was useful saying that ”it’s also just nice to be able to look at what the actual activities are.” The average rating for the usefulness of the tool obtained from the experts was 5/5.

Ease of use: Since all participants were able to successfully complete the outlined tasks, the design of the tool improved in terms of ease of use and intuitiveness. This was confirmed by the participants with E2 saying that the tool is ”much clearer now” and ”better organized” and E3 mentioning that ”it looks much more professional.” E1 also appreciated how the ethics topics were displayed as tags stating that ”it does feel quite familiar and it looks really clean.” E3 also mentioned that they like how ”the menu is always available.” The participants also gave an average rating of 4.67/5 for ease of use.

Usability issues: Despite the participants’ positive attitudes towards the tool, they identified some minor usability issues which could be easily fixed in the future. Links within text for proposing activities and ethics topics were not very visible (E1, E3), the selection box for ethics topics when proposing activities is very sensitive so it is easy to accidentally select/deselect a topic (E3), *Name* field in the proposing activity form suggests including a full name, not a forename (E1), buttons included in the pop-up confirming a successful submission for an activity/ethics topic are not clear (E1, E3).

Suggestions for future improvements: The participants also had some interesting suggestions for how the tool could be improved and developed in the future. Some recommendations have already been added to the list of requirements and marked as future work during the low-fidelity prototype evaluation.

Ethics topics: Both E1 and E2 suggested that it may not be straightforward what is meant by some of the ethics topics with E2 mentioning that a ”topic can be expressed in many ways.” Thus, they suggested including descriptions for the ethics topics and potentially having a list of subtopics for each high-level one. This could potentially solve an issue of people proposing topics with different names but meanings very similar to those already included in the tool. To ease the process of approving or rejecting ethics topics, E2 suggested having a ranking system which would calculate the number of times a specific topic was proposed. As mentioned by E2, the tool could also ”group (the ethics topics) so that you can see how many people propose quite the same topic.”

Including additional resources on computer ethics: Similarly to the low-fidelity prototype evaluation, E3 stressed the importance of adding associated reading on computer ethics to motivate the necessity of including these topics in curricula throughout the tool. They suggested that the home page should ”include some quick links to some reading about ethics to keep me engaged.”

Integrating the tool with other university systems: E3 suggested that the tool could be

integrated with other university systems, e.g. DRPS to ensure that course descriptions are accurate and updated. This was also mentioned by E1 who suggested including dates for when the system was last updated to ensure ”that this course still does this activity.” E3 proposed including a form for course organisers who could self-report on when and how they include ethics activities in their courses. This form should also include a reference to the tool with information on what ”topics are missing in the year that you are teaching, that you may consider integrating.” E3 expressed that this could further encourage course organisers to include more ethics in their courses.

Providing an option for cross-university teaching: E1 suggested that it would be interesting to make the tool ”open to the world” and used by different universities across the country. They suggested that in this situation it would be beneficial to include a ”comment or review feature” where professors from different institutions could share how they implemented different activities in their courses and how well the students received them. E1 also proposed including curriculum maps for ”comparing or contrasting between universities” to show differences in the curricula used at different institutions in the UK.

6.4 System Usability Scale Questionnaire

6.4.1 Aims

- Evaluate the system with Informatics students
- Measure the usability of the system
- Gather quantitative data to evaluate the tool
- Gather ideas for improvement

6.4.2 Participants

As mentioned earlier, the SUS questionnaire was given to all experts who participated in the evaluation described in section 6.3. Additionally, five informatics students with different backgrounds, two of whom participated in the cognitive walkthrough, were asked to interact with the tool and further fill out the questionnaire. Thus, giving a total number of 8 participants.

6.4.3 The Questionnaire

The first part of the questionnaire included ten system usability statements constructed by John Brooke in 1996 [49]. Each participant gave a score based on how much they agreed with each statement from *Strongly Disagree* to *Strongly Agree*. All participants were given a Participant Information Sheet and consented to take part in this study (Appendix I). The second part of the questionnaire included 4 optional questions about the participant’s experience when using the tool and ideas for future improvements. The full questionnaire can be found in Appendix J.2.2.

6.4.4 Data Collection and Analysis

The participants' answers were first converted from the *Strongly Disagree - Strongly Agree* scale to a 1-5 scale. For each participant, a SUS score was computed individually, using the formula established by Brooke [49], which can be found in Appendix J.2.1. These results were further analysed in terms of categories developed by Bangor, Kortum and Miller who determined the relationship between the SUS scores and adjectives (”good”, ”poor”, ”excellent” etc.) used by users to evaluate the systems they were interacting with [50, 51]. A mean was further calculated to establish the final score the tool obtained to determine its usability.

6.4.5 Results

The exact results of the SUS form are shown in Table 6.1. The lowest and highest scores are underlined showing that the results range from 82.5-100. Thus, seven ratings fall in the *Best Imaginable* category with one in the *Excellent* category. The mean for all participants gives an overall score of 91.875, which falls in the *Best Imaginable* category and is also shown in Figure 6.8 against the categories developed by Bangor, Kortum and Miller [50]. These results indicate the tool is acceptable in terms of usability.

Participant	1	2	3	4	**5**	**6**	**7**	8
Result	90	85	100	82.5	92.5	95	95	95

Table 6.1: Results of the SUS questionnaire by participant. Experts submitted the bolded results.

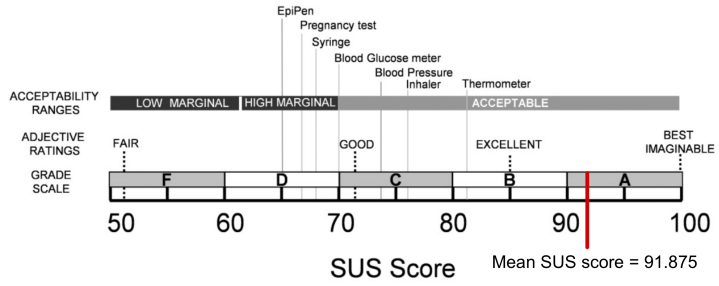


Figure 6.8: SUS mean score against the categories [50]

Out of 8 participants, 5 provided answers to all optional questions and 1 provided an answer to the second question. The obtained answers are summarised below.

Which curriculum map did you find easiest to use? 3 participants indicated that they found the table view easier to navigate, with one stating ”It was clearer to me what courses there were.” 2 participants expressed their preference towards the heat map with one participant mentioning that the ”heatmap was more intuitive due to the use of colour and summary statistics.” These answers further confirm the need for complementary visual representations, since different people find different graphs easier to interpret.

Did you find the information on the website understandable? All participants stated that they found the information understandable with one participant crediting ”the

clear, logical, uncluttered layout" for making things clear to them. Another participant stated that "the information was easy to understand and can be used by anyone." One participant mentioned that they were slightly "confused with ethics tags when proposing a new ethics topic, but quickly realized what's going on."

Which features did you like the most/found most useful? Participants indicated a variety of different features as the most useful ones with some mentioning the heat map "as it was able to clearly show the number of courses that cover each ethics topic in each semester." One participant also mentioned that "seeing the linkage between topics, module descriptions and courses, especially over the whole programme" was very useful. One participant also mentioned that they liked how the displayed information could be customised with another saying that they appreciated having an option to filter the views by ethics topics.

What are your suggestions for future improvements? The participants also had some ideas for future improvements with one suggesting adding "more tags to the activities to let the user know if it's a lecture/assignment etc." A different user suggested supporting filtering activities and courses by ethics topics which has already been added to the requirements and marked as future work. Another user also suggested including a separate page with a list of degrees, since as the system grows "it could be harder to find them using a drop-down."

6.5 Discussion

The main aim of this study was to evaluate the final version of the tool and determine whether it is viable for release. It was also helpful in gathering ideas for new features that could be labelled as further work. All experts really enjoyed interacting with the tool and had no issue completing presented tasks giving the tool an overall average rating of 4.5/5. The mean score of 91.875/100 received from the SUS form also indicates the tool to be viable and ready for release.

As mentioned in the literature review, curriculum maps are often used as a way to support collaboration when assessing and designing curricula [29]. This was also proved by the study with experts giving a 5/5 rating on the usefulness of the tool and praising the curriculum maps for clearly showing them when certain ethics topics are being delivered for different degree programmes. They also identified the *Topic Recommendations* feature to be particularly useful during the collaborative process of designing curricula.

The participants had varying opinions on which curriculum map (table view or heat map) was the most user-friendly. This again proves the need for accommodating different user experiences when it comes to visualisations.

These results combined indicate that the tool is viable for release and met its major requirements which was proven using both qualitative and quantitative data.

Chapter 7

Conclusions

This chapter will answer the research questions established in Chapter 1, describe the limitations of the project and ideas for further work.

7.1 Research Questions

RQ1: What are the available tools and approaches used in delivering ethics training to computer science students?

This research question was answered through the analysis included in the literature review in Chapter 2. It was established that different higher education institutions take different approaches to delivering computer ethics [1, 19]. Embedded ethics was identified as an innovative approach growing in popularity in North America [7, 8, 9, 10, 11]. However, it has not yet been applied in the United Kingdom. Advantages and limitations to existing online resources on computer ethics were also analysed. The literature review also established a lack of resources and research on approaches to teaching computer ethics used in Europe (and the UK) [1].

RQ2: What approaches are most widely used by higher education institutions in the United Kingdom?

This research question was answered through the studies conducted and described in Chapter 3 which made an effort to close the existing research gap mentioned earlier. The survey established that most undergraduate computer science students attending the participating institutions are exposed to some form of ethics training. The interviews revealed challenges computer ethics course organisers face when considering applying the embedded ethics approach at their institutions. The curriculum analysis gave insights into high-level topics commonly covered by computer ethics courses.

RQ3: Which approaches for displaying curriculum maps are most effective?

3 visualisations for curriculum maps were designed based on different methodologies and proposed for the low-fidelity prototype (Chapter 5). The evaluation studies conducted in Chapter 5 and Chapter 6 established that users have different preferences

when it comes to curriculum map visualisations. Thus indicating that it is not possible to choose one approach which would be considered *the best*.

RQ4: What are the requirements of the tool?

The requirements for the tool were all described alongside the reasoning for their inclusion in Chapter 4.

RQ4.1: How should it combine resources for delivering ethics training and curriculum mapping?

The requirements for the tool were gathered based on the challenges identified during the interviews described in Chapter 3 and available resources on computer ethics. Allowing course organisers to collaboratively share resources on computer ethics was combined with designing multiple visualisations for curriculum mapping as shown in Chapter 5 and Chapter 6.

RQ5: To what extent does the tool meet the requirements and support staff members and students in improving ethics training for computer science students?

The tool obtained an overall average rating of 4.5/5 from the experts and a mean score of 91.875/100 on the SUS form. Thus, suggesting that the tool met the established requirements.

RQ5.1: Does the tool encourage a more collaborative approach to course design?

The tool received a rating of 5/5 in the usefulness category. The experts identified curriculum maps as a great way to inform course organisers about what is delivered in different degree programmes. The *Topic Recommendations* feature was also recognised to potentially support discussions in boards of studies. The experts also liked the idea of collaboratively sharing ideas for activities on ethics.

7.2 Limitations

Due to time constraints, there are some important limitations to the presented work that need to be considered. Some suggestions obtained during the low-fidelity prototype evaluation have been marked as *Future Work* since not all features could have been implemented in the time frame given for this project. The current version of the tool does not include true information on ethics topics covered by computer science degree programmes at the university. Before release the database would have to be seeded in collaboration with computer science course organisers who would self-report ethics topics they cover in their courses. EASE authentication was added to the tool as a proof of concept and would have to be integrated with the system before the release. Additionally, the tool does not have an implemented admin version thus all ethics topics and activities have to be approved directly through the database which is not ideal. There are also some limitations to the evaluation studies conducted for this project. Firstly, the high-fidelity prototype was evaluated by the same experts who had already participated in the low-fidelity prototype evaluation studies. Thus, it is possible that the design of the low-fidelity prototype influenced the decisions they made when interacting with the high-fidelity prototype.

7.3 Further Work

Even though the current version of the tool is viable for release, some additional features could improve user experience and extend the applicability of the tool in future releases. Firstly, the database would have to be seeded with course descriptions available through DRPS and self-reported information on ethics topics covered in different computer science courses. Additionally, the suggestions marked as *Future Work* should be implemented to further improve the tool. The recommendations established through the high-fidelity prototype evaluation should also be analysed. Thus, a decision on which suggestions would be added to the list of requirements should be made. To decide on what other curriculum mapping visualisations should be available, a design workshop with course organisers and programme designers should be conducted [52] and the chosen visualisations should be implemented to enable further customisation. Adding an admin view would enable authorised faculty members to easily manage the tool ensuring that all provided information was up to date. They would also be allowed to approve or reject proposed ethics topics and activities. Following the first release of the tool, an in-depth evaluation study should be conducted to ensure the tool supports programme designers and course organisers in integrating ethics throughout computer science degrees. Successful reception of the tool at The University of Edinburgh could lead to extending its use to other institutions across the country. Thus, the need for shared resources on computer ethics, established during the interview stage of the study (Chapter 3), would be met. In agreement with participating higher education institutions the tool could also provide curriculum maps for comparing computer ethics curricula [27] at different higher education institutions in the UK.

7.4 Conclusion

This project investigated approaches used in delivering computer ethics training to undergraduate students in the United Kingdom and further identified challenges faced by professors who attempt to integrate ethics into computer science curricula. Some of these issues were addressed through the development of a viable tool which enables course organisers to share resources on computer ethics. The tool also promotes more collaborative approaches to designing programme curricula by allowing course organisers and programme designers to view curriculum maps on ethics topics covered by different degree programmes at the university. The tool was further evaluated by experts in HCI and education and informatics students. These studies suggest the tool encourages more collaborative approaches to designing curricula when it comes to delivering ethics training to computer science students.

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Appendix A

Questionnaire on ethics training for computer science students

Ethics training for computer science students

* Required

Participant Information Sheet (page 1)

Project title: Research into ethics training offered by different universities in the UK
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter

This study was certified according to the Informatics Research Ethics Process, reference number **889516**. Please take time to read the following information carefully. You should keep this page for your records.

What is the purpose of the study?
I would like to research ways in which different institutions in the United Kingdom provide their computer science students with ethics training.

Why have I been asked to take part?
For this research, I chose numerous faculty member at different institutions who, from my previous research, seemed involved in computer science ethics or professional issues.

Do I have to take part?
No – participation in this study is entirely up to you. You can withdraw from the study at any time, up until 04.04.2024 without giving a reason. After this point, personal data will be deleted and anonymised data will be combined such that it is impossible to remove individual information from the analysis. Your rights will not be affected. If you wish to withdraw, contact the PI. We will keep copies of your original consent, and of your withdrawal request.

What will happen if I decide to take part?
In the next section I will ask you a couple of questions on the ways in which ethics is included in the computer science curriculum at your institution. This should take approximately 15 minutes. If you wish to be contacted by me to schedule an interview/discussion on the topic, you can provide your contact details below.

Are there any risks associated with taking part?
There are no significant risks associated with participation.

What will happen to the results of this study?
The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a maximum of 4 years. All potentially identifiable data will be deleted within this timeframe if it has not already been deleted as part of anonymization.

Data protection and confidentiality.
Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team: Zofia Kniter and James Garforth. All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint).

Participant Information Sheet (page 2)

What are my data protection rights?
The University of Edinburgh is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

Who can I contact?
If you have any further questions about the study, please contact the lead researcher, Zofia Kniter, s2094204@ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

Updated information.
If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.inf.ed.ac.uk/infweb/research/study-updates.

Alternative formats.
To request this document in an alternative format, such as large print or on coloured paper, please contact me at s2094204@ed.ac.uk

General information.
For general information about how we use your data, go to: edin.ac/privacy-research

Participant Consent Form

Project title: Research into ethics training offered by different universities in the UK
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter
PI contact details: james.garforth@ed.ac.uk

By participating in the study you agree that:

- I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.
- My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.
- I consent to my anonymised data being used in academic publications and presentations.
- I understand that my anonymised data will be stored for the duration outlined in the Participant Information Sheet.

1. I agree to take part in this study *

- ◯ Yes
- ◯ No

Start of the survey

In this survey Ethics is meant as a broad umbrella term for all topics that involve considering ethical issues in technology as well as the impact technology has on society. Courses/topics taught at your institution do not necessarily have to include philosophical dilemmas/discussions in the curricula to be considered a part of Ethics training for Computer Science students.

2. Please type in the name of your institution *

3. Does the Computer Science programme (or equivalent) taught at your institution include references to topics regarding ethics in technology/technology and society? *

- ◯ Yes
- ◯ No

4. When does the School aim to introduce undergraduate computer science students to the concepts of Ethics in technology? *

- ◯ Year 1
- ◯ Year 2
- ◯ Year 3+

5. Does the School offer a dedicated course in Ethics aimed at computer science students? *

- ◯ Yes
- ◯ No

6. Is this dedicated course compulsory? If the programme has both a compulsory and optional course, choose Yes *

- ◯ Yes
- ◯ No

7. Does the programme have both a compulsory and an optional course? *

- ◯ Yes
- ◯ No

8. When is the optional course usually taken by students? *

- ◯ Year 1
- ◯ Year 2
- ◯ Year 3+

9. When is the compulsory course usually taken by students? *

- ◯ Year 1
- ◯ Year 2
- ◯ Year 3+

10. When is the course usually taken by students? *

- ◯ Year 1
- ◯ Year 2
- ◯ Year 3

11. If possible, could you provide a link to the website/syllabus for the course(s) or describe the learning outcomes?

12. Are there any computer science courses in the School that include at least one class dedicated to Ethics? *

- ◯ Yes
- ◯ No
- ◯ I am not sure

13. If Yes, could you provide some examples?

14. Are the classes on Ethics examinable? *

- ◯ Yes, all of them
- ◯ Yes, but only some of them
- ◯ No
- ◯ I am not sure

15. If there are no dedicated courses, explain how the programme aims to introduce students to the concepts of Ethics or aid discussions on the impact of technology on society.

16. If you are happy to be contacted later on to potentially answer more questions/arrange an interview, please provide your email address here.

Appendix B

Participant Information Sheet and Consent Form for interviews with ethics course organisers

Ethics courses for computer science students interview

* Required

Participant Information Sheet (page 1)

Project title: Research into ethics training offered by different universities in the UK
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter

This study was certified according to the Informatics Research Ethics Process, reference number **889516**. Please take time to read the following information carefully. You should keep this page for your records.

What is the purpose of the study? I would like to research ways in which different institutions in the United Kingdom provide their computer science students with ethics training and create a tool which would allow faculty members to access multiple resources regarding Ethics in technology.

Why have I been asked to take part? For this research, I chose numerous faculty member at different institutions who, from my previous research, seemed involved in computer science ethics or professional issues.

Do I have to take part? No – participation in this study is entirely up to you. You can withdraw from the study at any time, up until 04.04.2024 without giving a reason. After this point, personal data will be deleted. Your rights will not be affected. If you wish to withdraw, contact the PI. We will keep copies of your original consent, and of your withdrawal request.

What will happen if I decide to take part? I will conduct a 30-45 minute interview asking questions about the course/modules you deliver and your opinions on what the content of such courses should be. I will also ask questions on the design of the tool and will ask about your opinion on what the tool should look like.

Are there any risks associated with taking part? There are no significant risks associated with participation.

What will happen to the results of this study? The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a maximum of 4 years. All potentially identifi-able data will be deleted within this timeframe if it has not already been deleted as part of anonymization.

Data protection and confidentiality. Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team: Zofia Kniter and James Garforth. All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint).

Participant Information Sheet (page 2)

What are my data protection rights? The University of Edinburgh is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

Who can I contact?If you have any further questions about the study, please contact the lead researcher, Zofia Kniter, s2094204@ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

Updated information. If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.in-f.ed.ac.uk/infweb/research/study-updates.

Alternative formats. To request this document in an alternative format, such as large print or on coloured paper, please contact me at s2094204@ed.ac.uk

General information. For general information about how we use your data, go to: edin.ac/privacy-research

Participant Consent Form

Project title: Research into ethics training offered by different universities in the UK
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter
PI contact details: james.garforth@ed.ac.uk

By participating in the study you agree that:

1. I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.

2. My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.

3. I consent to my anonymised data being used in academic publications and presentations.

4. I understand that my data will be stored for the duration outlined in the Participant Information Sheet.

1. Please enter your name *

2. I agree to take part in this study *

- ◯ Yes
- ◯ No

3. I agree for the interview to be recorded *

- ◯ Yes
- ◯ No

Appendix C

Questions asked during the interviews with ethics course organisers

Due to the semi-structured nature of the interviews, some questions were phrased differently during the discussions. However, themes present in these questions were all covered during the interviews.

- How would you define ethics? And how does that definition change when you put it in the context of technology/computer science?
- Why do you believe it is important to teach ethics to Computer Science students?
- More and more companies are hiring Ethics professionals who review their designs. Does that change your view on the importance of teaching ethics?
- What methods are in your opinion most effective?
- What are the most important topics that should be included in the ethics curriculum for CS students? What guided you in choosing the topics you covered?
- What is the composition of the team delivering the course? Is it cross-disciplinary?
- How well prepared are students to take the course based on the education system?
- How is the course/submodule assessed?
- Do Computer Science students struggle with this type of material?
- Have you experienced any resistance from students? What topics are students resistant to/find most difficult?
- Do you know of any Computer Science courses which add modules on ethics at your institution?

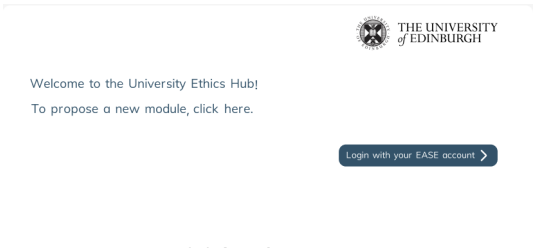
Appendix D

10 Nielsen Heuristics [2]

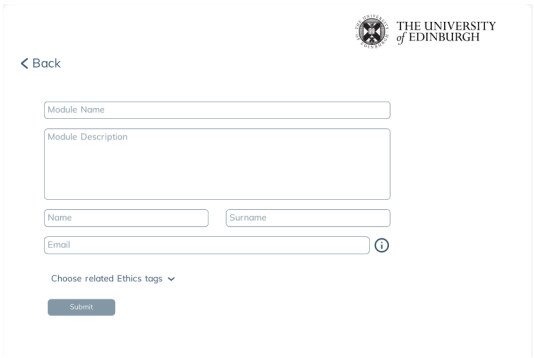
- N1: Visibility of System Status
- N2: Match Between the System and the Real World
- N3: User Control and Freedom
- N4: Consistency and Standards
- N5: Error Prevention
- N6: Recognition Rather than Recall
- N7: Flexibility and Efficiency of Use
- N8: Aesthetic and Minimalist Design
- N9: Help Users Recognize, Diagnose, and Recover from Errors
- N10: Help and Documentation

Appendix E

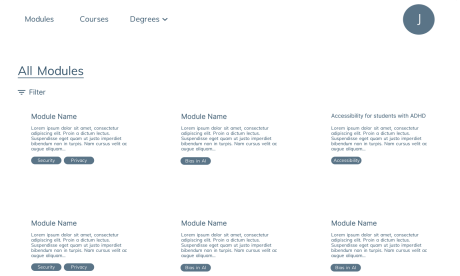
Screenshots of the low-fidelity prototype



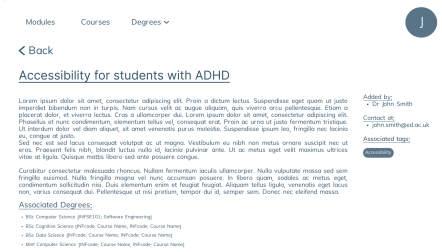
(a) Login page



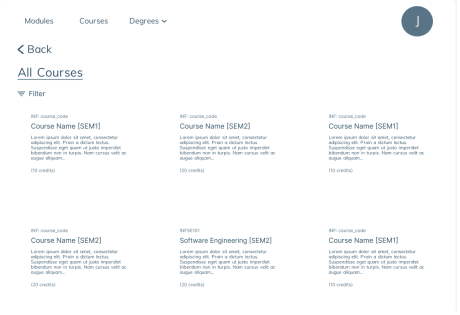
(b) Add activity page



(c) All activities page



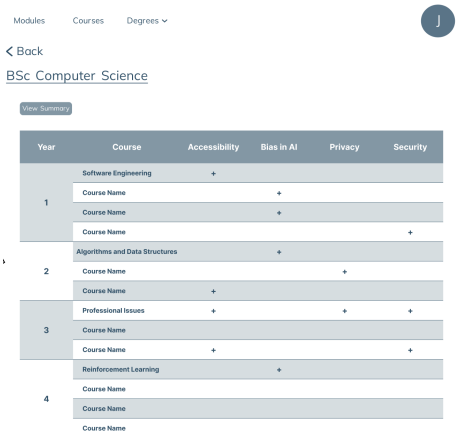
(d) Activity description page



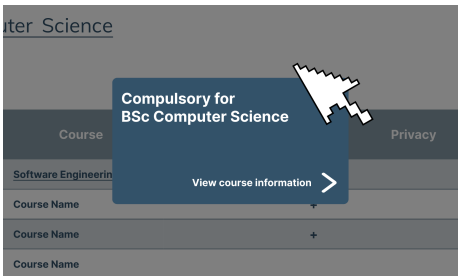
(e) All courses page

(f) Course description page

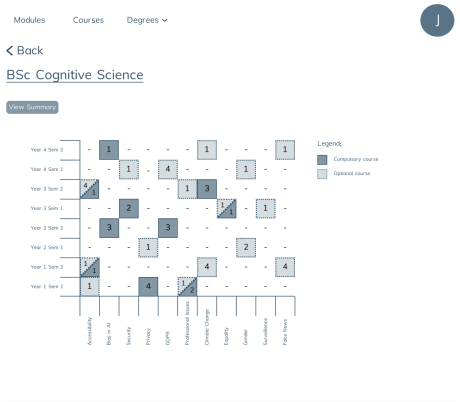
Figure E.1: Low fidelity prototype design 1



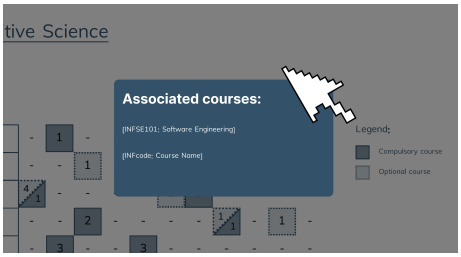
(a) Table View



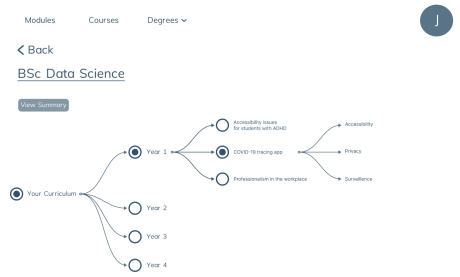
(b) Table View Pop Up



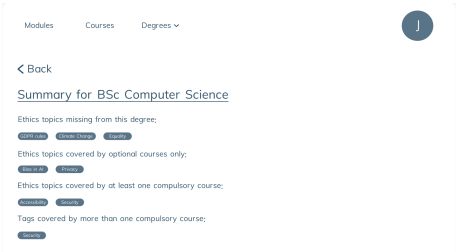
(c) Heat Map



(d) Heat Map Pop Up



(e) Curriculum Tree



(f) Summary of results

Figure E.2: Low fidelity prototype design 2

Appendix F

Participant Information Sheet and Consent Form for the cognitive walkthrough and sessions with experts

Ethics Tool Testing

* Required

Participant Information Sheet (page 1)

Project title: Testing of the Ethics Tool
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter

This study was certified according to the Informatics Research Ethics Process, reference number **891142**. Please take time to read the following information carefully. You should keep this page for your records.

What is the purpose of the study? The purpose of this study is to conduct a cognitive walkthrough and ab testing to make the most optimal design choices while implementing the Ethics Tool.

Why have I been asked to take part? For this research, I chose participants with some experience in Human Computer Interaction as well as faculty members who are the end-users for this app.

Do I have to take part? No – participation in this study is entirely up to you. You can withdraw from the study at any time, up until 04.04.2024 without giving a reason. After this point, personal data will be deleted. Your rights will not be affected. If you wish to withdraw, contact the PI. We will keep copies of your original consent, and of your withdrawal request.

What will happen if I decide to take part? I will conduct a 30-45 minute interview asking you to complete some tasks while using the app. I will ask for your opinions on the design choices as well. I will also observe how you interact with the app. The in-person interviews will be recorded as voice recording, transcribed within a week and further deleted. The interviews conducted online through Teams, will be recorded using Teams, transcribed and immediately deleted.

Are there any risks associated with taking part? There are no significant risks associated with participation.

What will happen to the results of this study? The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a maximum of 4 years. All potentially identifiable data will be deleted within this timeframe if it has not already been deleted as part of anonymization.

Data protection and confidentiality. Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team: Zofia Kniter and James Garforth. All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint).

Participant Information Sheet (page 2)

What are my data protection rights? The University of Edinburgh is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

Who can I contact?If you have any further questions about the study, please contact the lead researcher, Zofia Kniter, s2094204@ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

Updated information. If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.in-f.ed.ac.uk/infweb/research/study-updates.

Alternative formats. To request this document in an alternative format, such as large print or on coloured paper, please contact me at s2094204@ed.ac.uk

General information. For general information about how we use your data, go to: edin.ac/privacy-research

Participant Consent Form

Project title: Testing of the Ethics Tool
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter
PI contact details: james.garforth@ed.ac.uk

By participating in the study you agree that:

1. I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.

2. My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.

3. I consent to my anonymised data being used in academic publications and presentations.

4. I understand that my data will be stored for the duration outlined in the Participant Information Sheet.

1. Please enter your name *

2. I agree to take part in this study *

- ◯ Yes
- ◯ No

3. I agree for the interview to be recorded *

- ◯ Yes
- ◯ No

Appendix G

Evaluation of the Low Fidelity Prototype

G.1 Cognitive Walkthrough notes

These notes were taken during the cognitive walkthrough with 2 former HCI students. Their names which were initially included in the notes to keep track of who mentioned what were anonymised using identifiers shown in table 5.1

TASK 1: Propose a new module on Privacy and Security.

* step 1 - press "click here" on the log in page.

Q1: No - the "click here" might be hard to notice

Q2: No - again the "click here" is not super noticeable. users might try to log in straight away (P1) maybe underline?

Q3: Yes - once you notice the link, it is clear that you can propose a module

Q4: Yes - clearly can see the form.

* step 2 - Fill in the form

Q1: Yes

Q2: Yes

Q3: Yes

Q4: Yes

no issues here

* step 3 - choose Privacy and Security from the drop-down

Q1: Yes | No - yes, the label for the drop-down is clear (but maybe change to ethics topics)

Q2: Yes | No - same reason as above.

Q3: Yes - no issue with knowing more than one can be selected

Q4: Yes - clear what is selected or not selected

* step 4 - press SUBMIT

Q1 : Yes -

Q2 : Yes - clearly visible

Q3 : Yes

Q4 : No - there needs to be a pop-up for success

TASK 2 : Find a course with an activity on Accessibility delivered in Year 1 of BSc Computer Science and check if it is compulsory for this degree.

* step 1 - Log in to the tool

Q1 : Yes

Q2 : Yes

Q3 : Yes

Q4 : Yes

* step 2 - open the Degrees drop-down in the navbar

Q1 : Yes

Q2 : Yes

Q3 : Yes

Q4 : Yes

* step 3 - click BSc Computer Science

Q1 : Yes

Q2 : Yes

Q3 : Yes

Q4 : Yes

*step 4 - click software Engineering to view if compulsory

Q1: No - didn't notice it's clickable, would rather it would be immediately visible which courses are optional / compulsory (P2)

Q2: Yes / No - people with learning difficulties might struggle to find the name - no borders in the table (P1)

Q3: No - no indication that clicking the name will show if course is compulsory

Q4: Yes - the pop up was clear

TASK 3: Find names of courses delivered in Year 1 Semester 2 on Accessibility for BSc Cognitive Science

*step 1 - Log into the tool

Q1: Yes

Q2: Yes

Q3: Yes

Q4: Yes

*step 2 - open the Degrees drop-down in the navbar

Q1: Yes

Q2: Yes

Q3: Yes

Q4: Yes

*step 3 - click BSc Cognitive Science

Q1: Yes

Q2: Yes

Q3: Yes

Q4: Yes

* Step 4 – Click the cell with 1/1 in Year 1 Sem 2 and Accessibility

Q1: No – P2 said that new users won't realise that cells can be clicked

Q2: No – won't know that cells can be clicked

Q3: No – the pop-up isn't clear, might be better to underline the link to show that it can be clicked. Or give clear instructions (short instruction)

Q4: Yes

Note: * it wasn't obvious which course was the optional/compulsory one in the pop up. Did not like the hovering. Maybe better to show straight away what is compulsory/optional (like in the table)

* the green/red wasn't a great choice. Looks like one is right, the other is wrong

* P1 said that colours are not enough – patterns or borders could be added. (accessibility)

TASK 4: Find all topics delivered during the COVID-19 tracing app activity in Year 1 of BSc Data Science.

* step 1 - Log into the tool

Q1: Yes

Q2: Yes

Q3: Yes

Q4: Yes

* step 2 - open the Degrees drop-down in the navbar

Q1: Yes

Q2: Yes

Q3: Yes

Q4: Yes

* step 3 - click BSc Data Science

Q1: Yes

Q2: Yes

Q3: Yes

Q4: Yes

* step 4 - click Your curriculum radio button

Q1: No - it's confusing that there is a radio button, there should always be more than one option (P1)

Q2: No - users might not notice the button

Q3: Yes

Q4: Yes

* step 5 - click Year 1

Q1: Yes
Q2: Yes
Q3: Yes
Q4: Yes

afterwards it's easier to realise. maybe have Years open from the start?

* step 6 - click COVID-19 tracing app

Q1: Yes
Q2: Yes
Q3: Yes
Q4: Yes

Note: Both mentioned that the view could get confusing with more things added

G.2 Evaluation with Experts

G.2.1 Thinking Aloud tasks

- propose a new module, which will include topics on privacy and security
- find all modules associated with a course called Software Engineering
- find a degree for which all students on that degree are exposed to the Acessibility for students with ADHD module
- view the curriculum map for BSc Computer Science, find out if Software Engineering is compulsory for this degree and view the summary of results for this map
- view the curriculum map for BSc Cognitive Scienc, find courses which are delivered in year 1 semster 2 and include modules on Accessibility and try to analyse the map you are seeing
- view the curriculum map for BSc Data Science, find the topics covered during the modules on Covid-19 tracing apps delivered in Year and try to analyse the map you are seeing

G.2.2 Final questions

- Which map did you find most intuitive and easy to analyse?
- Was the summary of results helpful or would you rather perform such analysis by interacting with the map only? What other information could this summary include?
- Would this tool encourage you to include more Ethics modules in your courses or propose your own modules?
- Are there any other suggestions you could provide to improve the tool?

Appendix H

Screenshots of the high-fidelity prototype

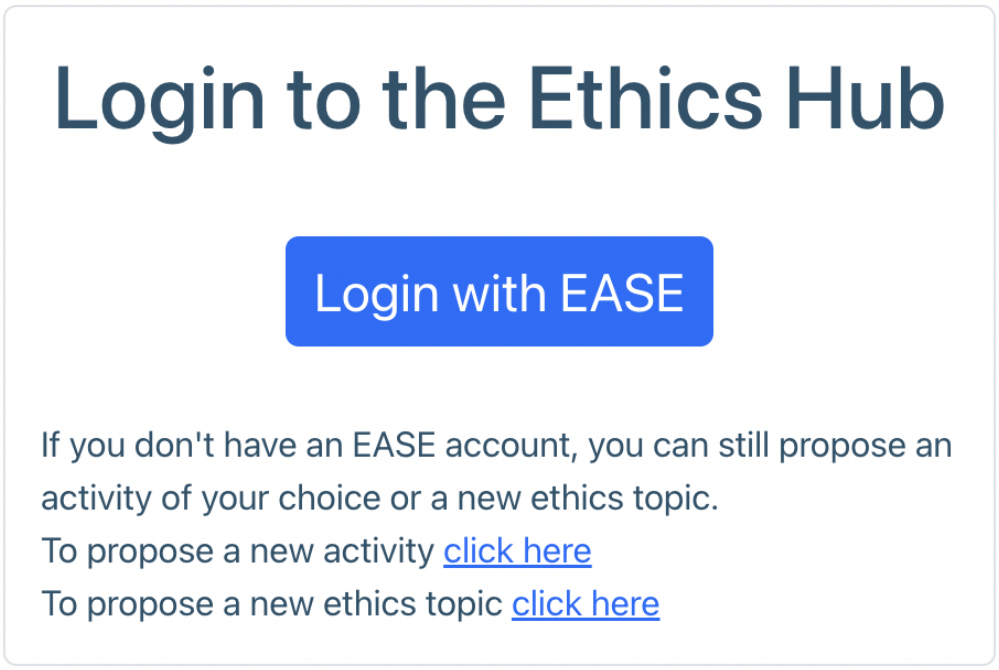


Figure H.1: High-fidelity prototype login page

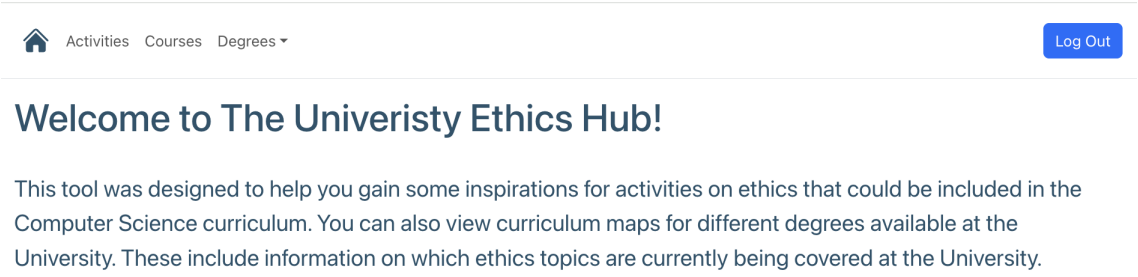


Figure H.2: High-fidelity prototype home page

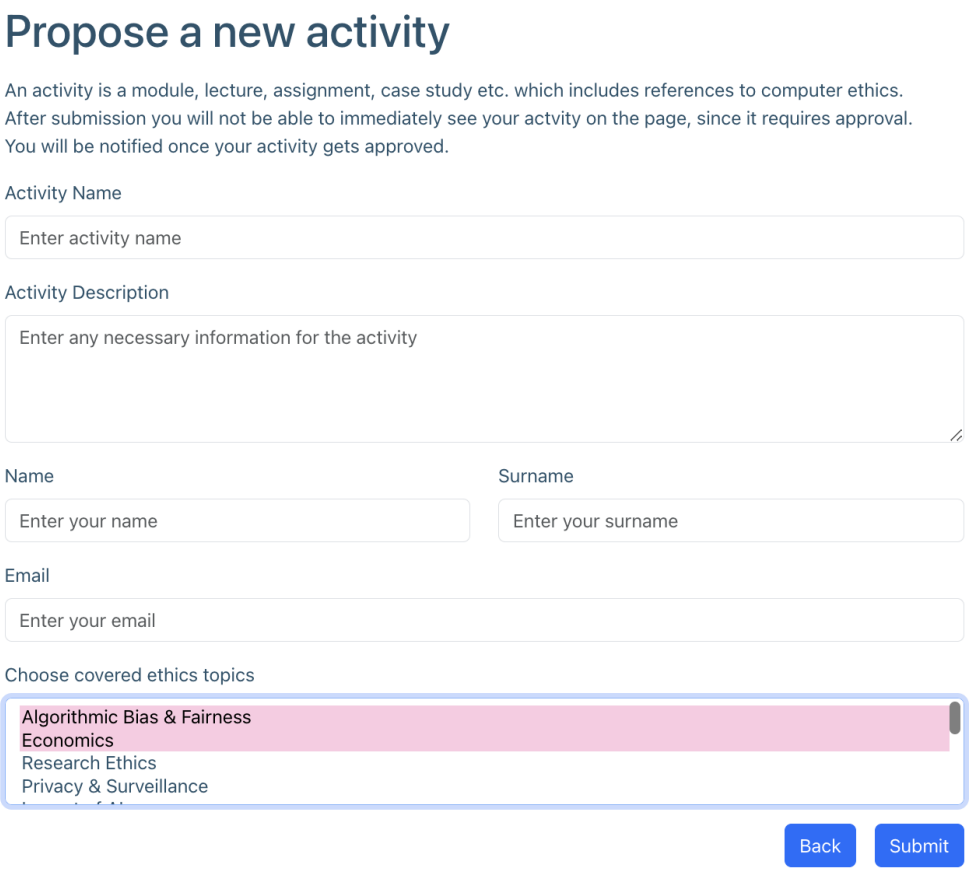


Figure H.3: High-fidelity prototype new activity proposal form

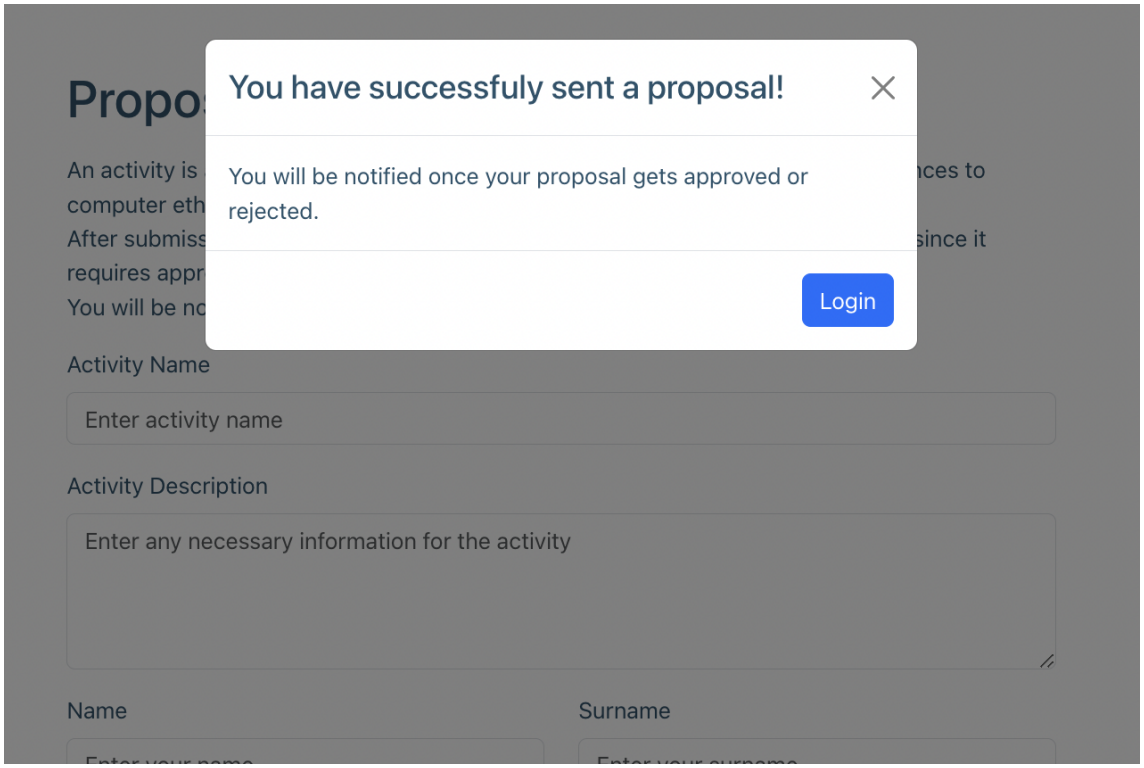


Figure H.4: High-fidelity prototype new activity proposal success pop-up

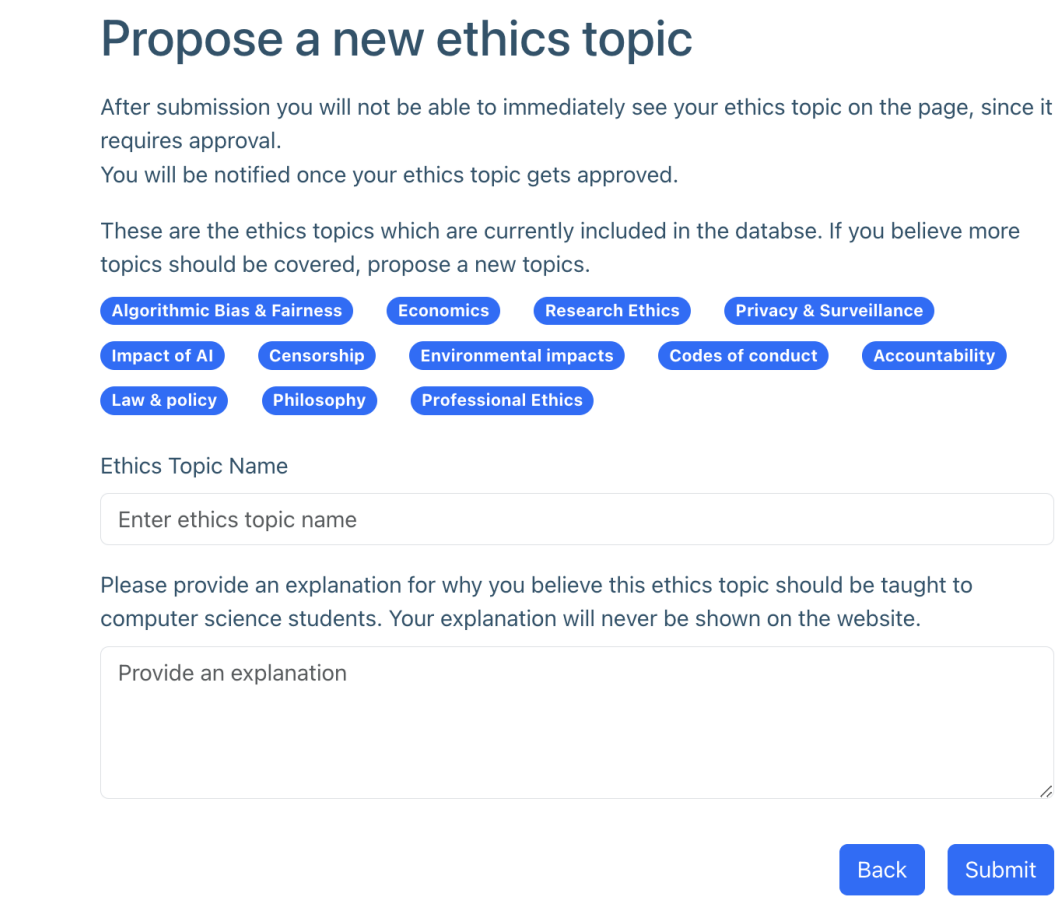


Figure H.5: High-fidelity prototype new ethics topic proposal

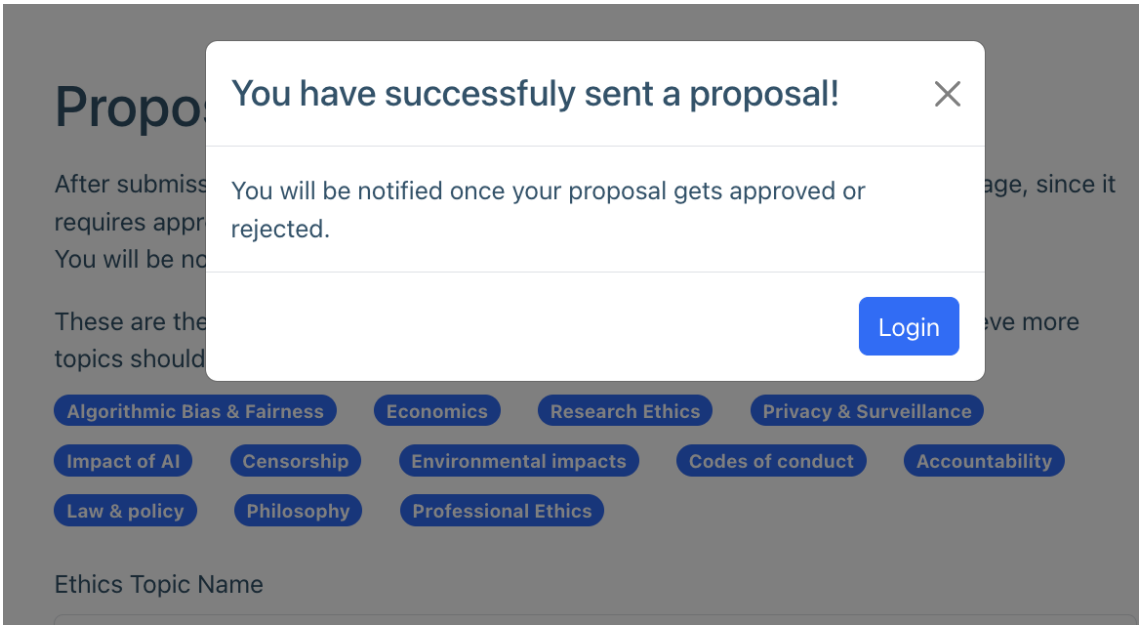


Figure H.6: High-fidelity prototype new ethics topic proposal success pop-up

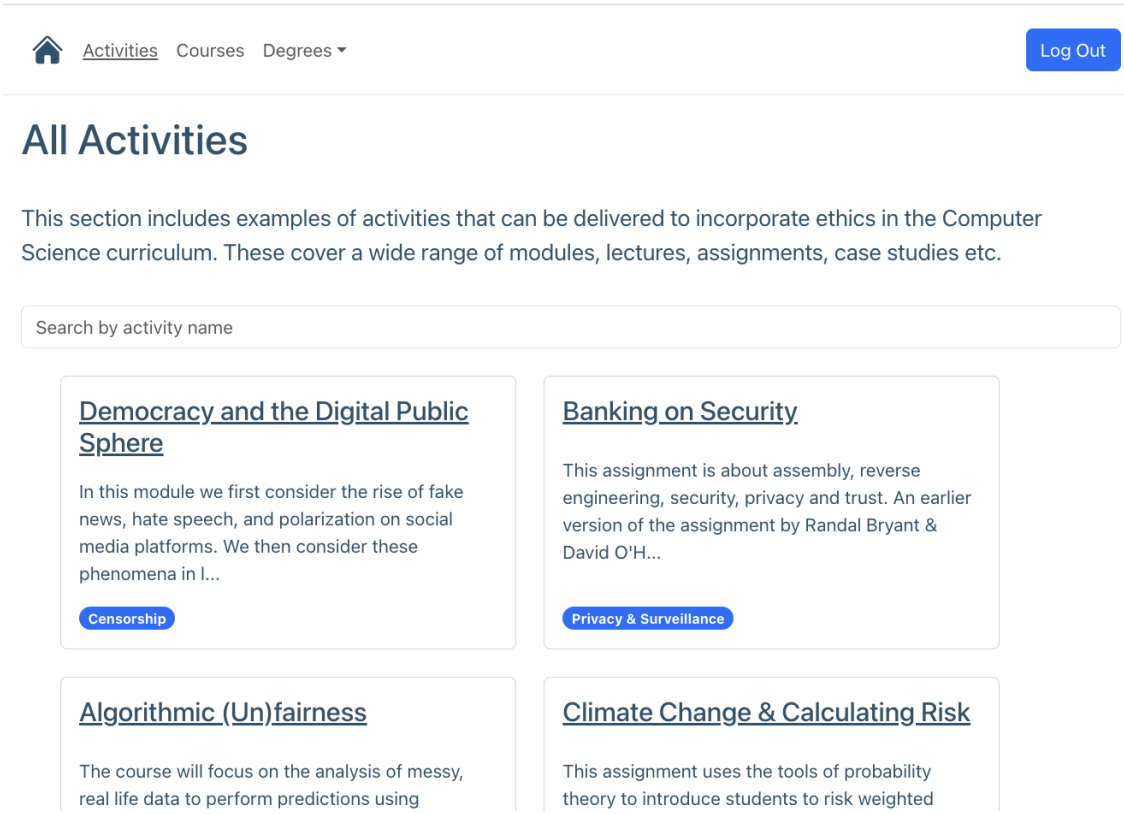


Figure H.7: All activities page

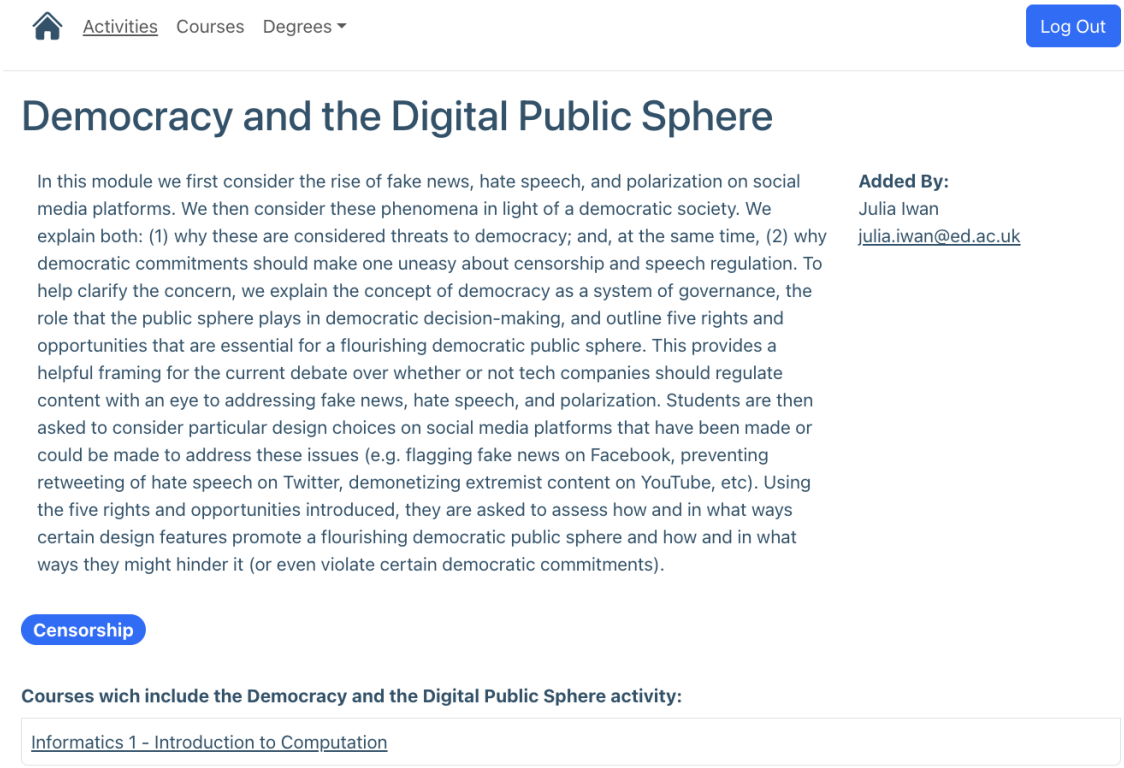


Figure H.8: Example of activity page

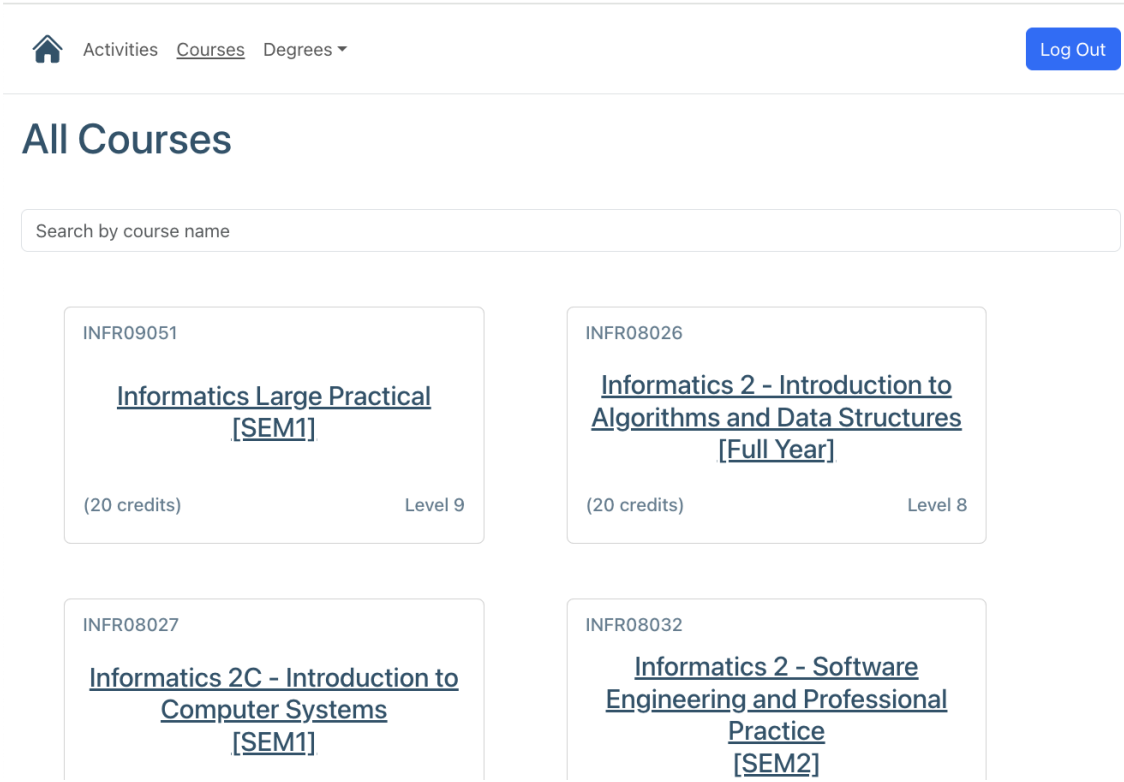


Figure H.9: All courses page

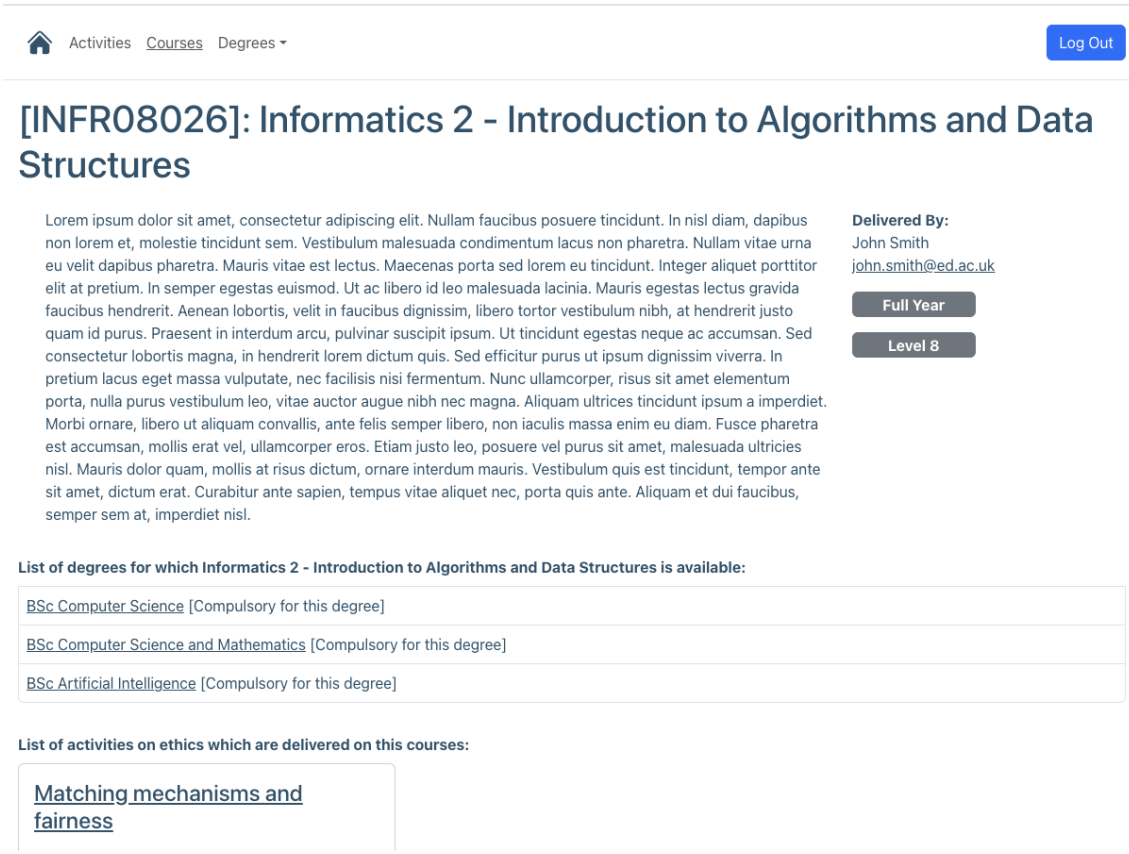
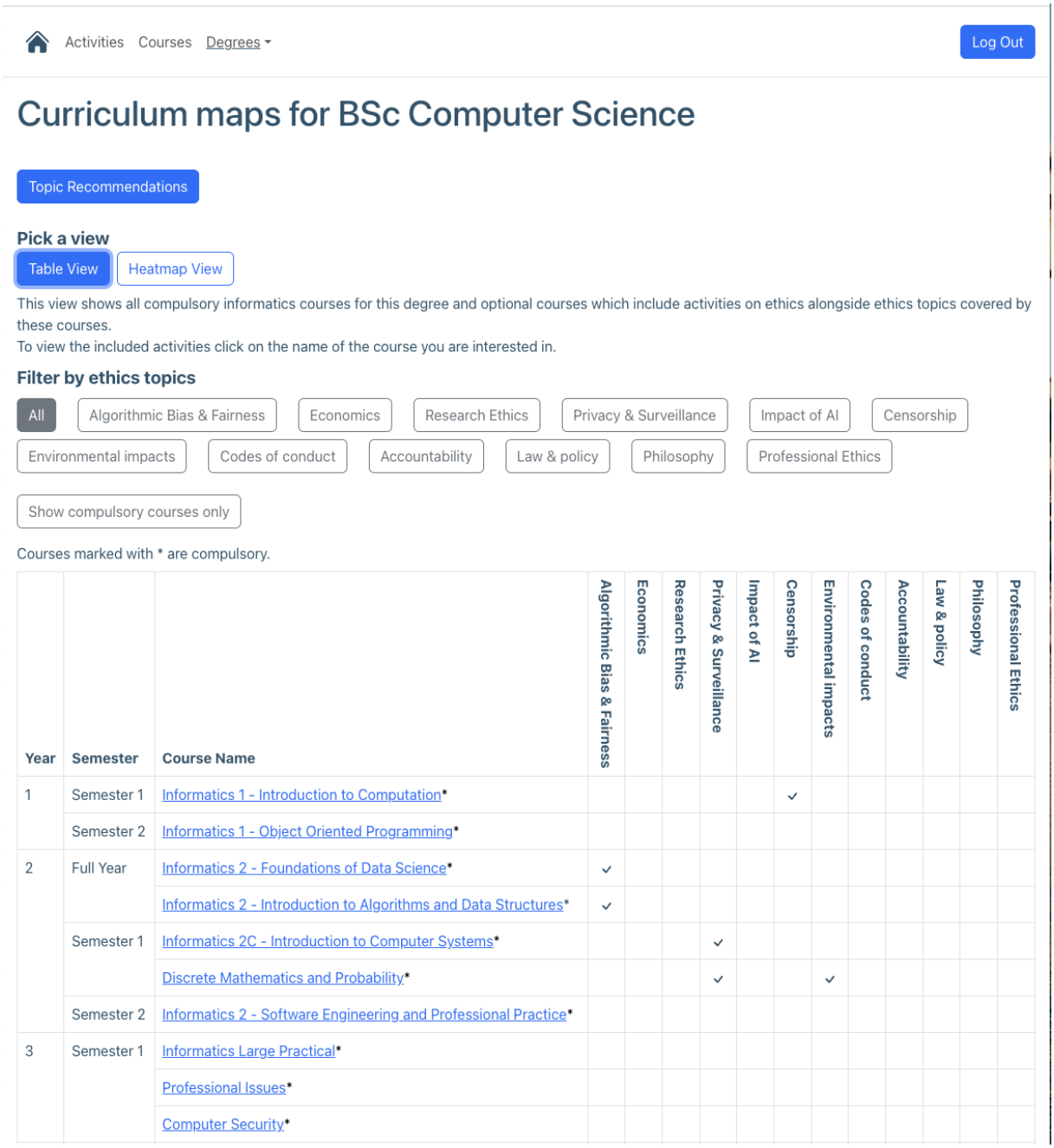


Figure H.10: Example of course page



Year	Semester	Course Name	Algorithmic Bias & Fairness	Economics	Research Ethics	Privacy & Surveillance	Impact of AI	Censorship	Environmental impacts	Codes of conduct	Accountability	Law & policy	Philosophy	Professional Ethics
1	Semester 1	Informatics 1 - Introduction to Computation*						✓						
	Semester 2	Informatics 1 - Object Oriented Programming*												
2	Full Year	Informatics 2 - Foundations of Data Science*	✓											
		Informatics 2 - Introduction to Algorithms and Data Structures*	✓											
	Semester 1	Informatics 2C - Introduction to Computer Systems*				✓								
		Discrete Mathematics and Probability*				✓			✓					
	Semester 2	Informatics 2 - Software Engineering and Professional Practice*												
3	Semester 1	Informatics Large Practical*												
		Professional Issues*												
		Computer Security*												

Figure H.11: Example for a table view

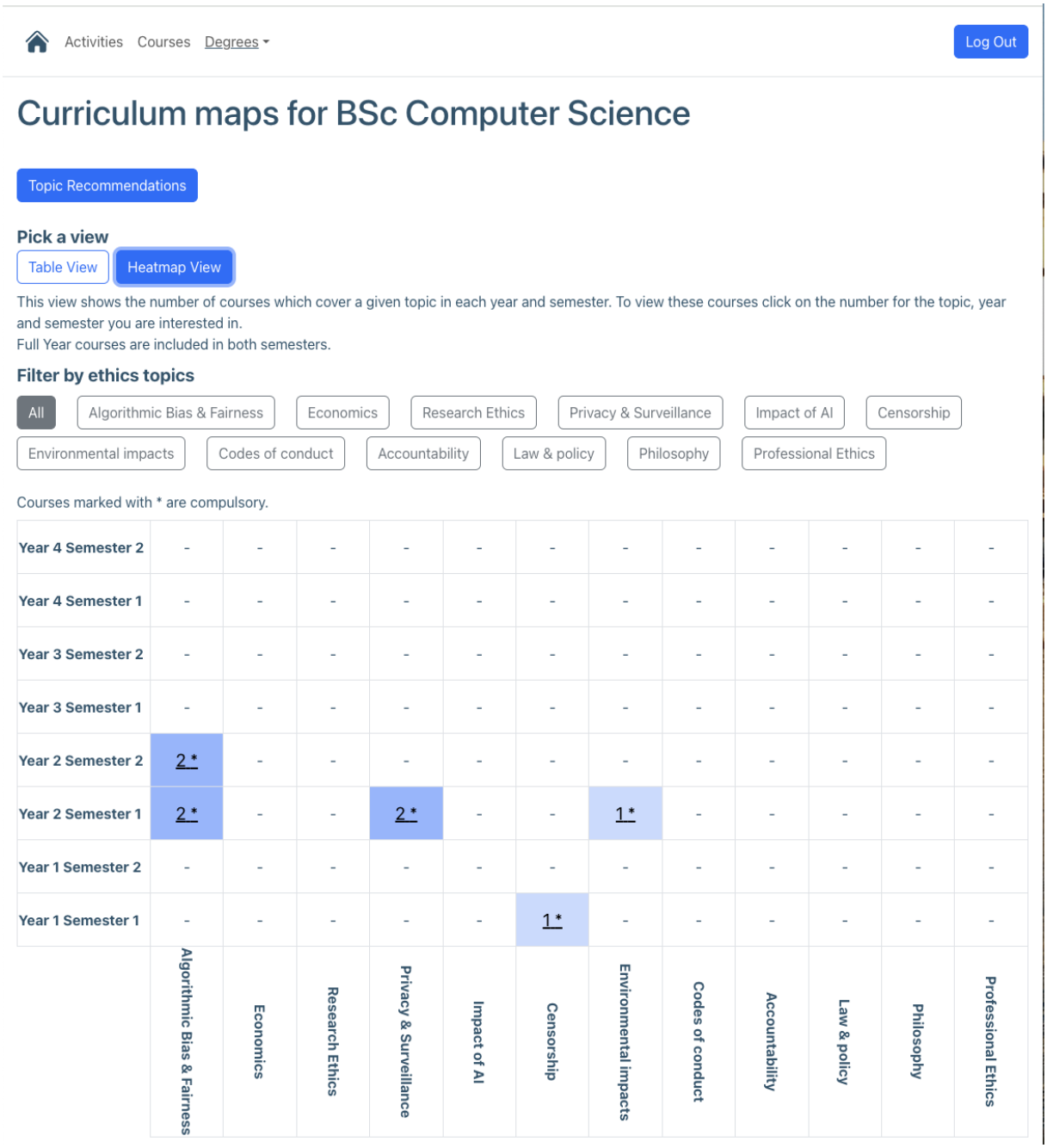


Figure H.12: Example for a heat map

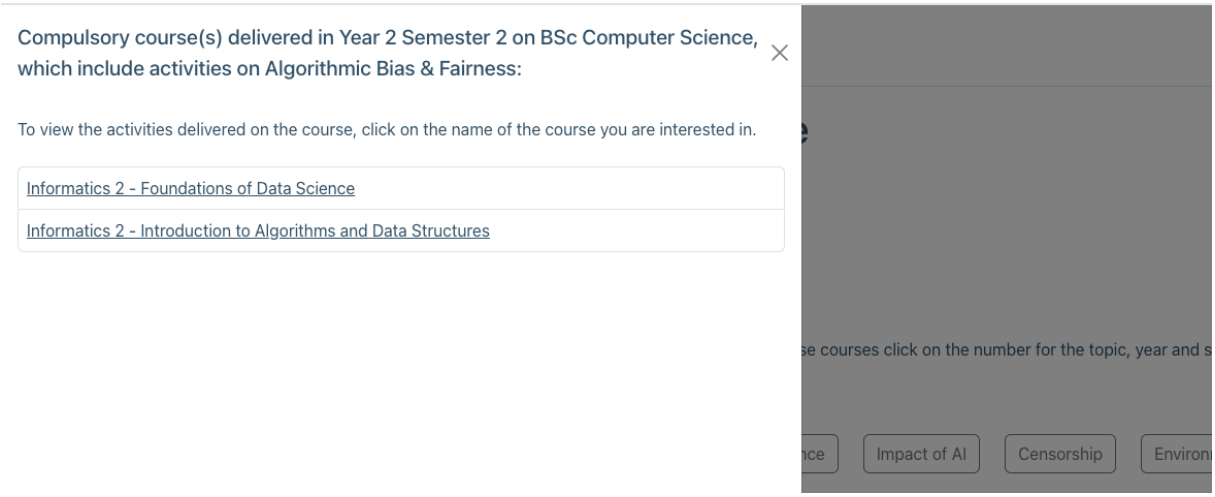


Figure H.13: Example for a heat map overlay

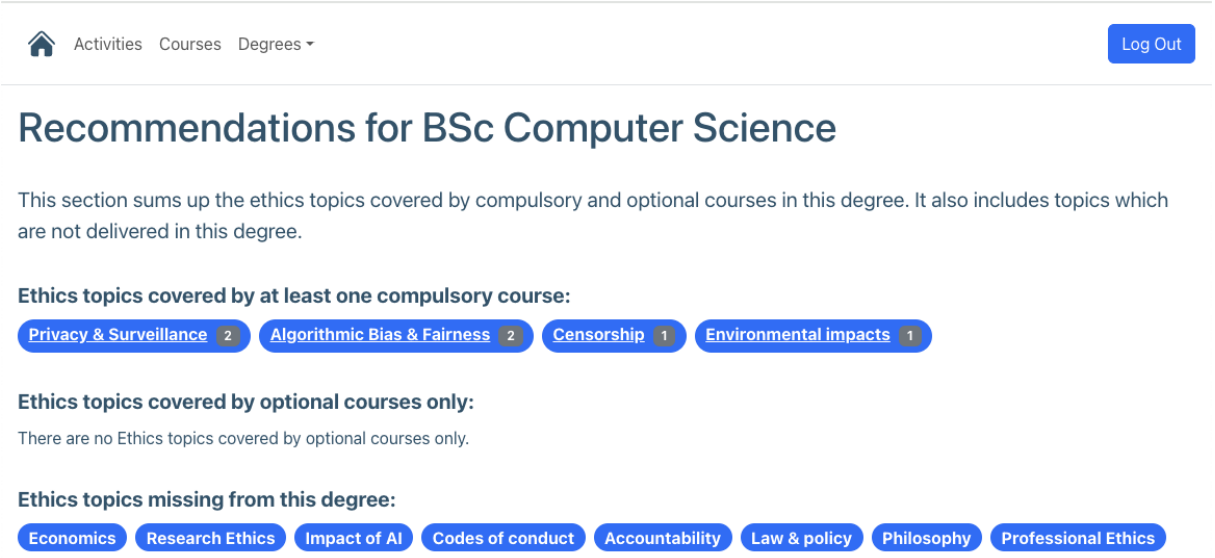


Figure H.14: Example for a topics recommendations page

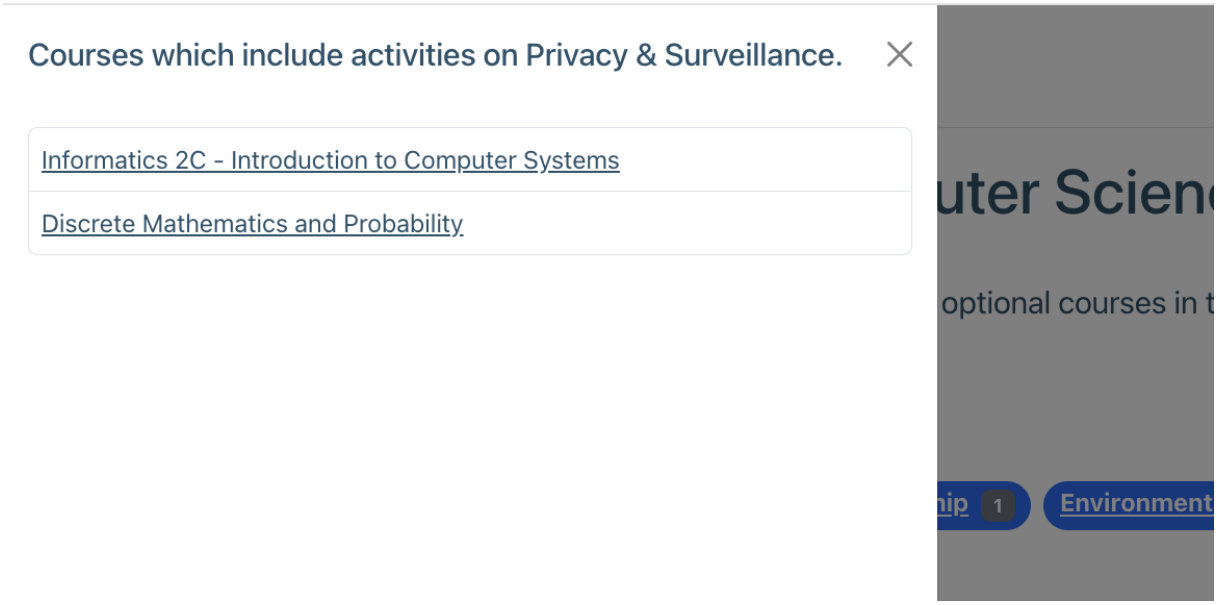


Figure H.15: Example for a topics recommendations page

Appendix I

Participant Information Sheet and Consent Form for the SUS questionnaire

Ethics Tool Usability Testing

* Required

Participant Information Sheet (page 1)

Project title: Testing of the Ethics Tool
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter

This study was certified according to the Informatics Research Ethics Process, reference number **891142**. Please take time to read the following information carefully. You should keep this page for your records.

What is the purpose of the study? The purpose of this study is to conduct Usability Testing for the Ethics Tool.

Why have I been asked to take part? For this research, I chose numerous students and faculty members, to provide feedback on the usability of this tool.

Do I have to take part? No – participation in this study is entirely up to you. You can withdraw from the study at any time, up until 04.04.2024 without giving a reason. After this point, personal data will be deleted. Your rights will not be affected. If you wish to withdraw, contact the PI. We will keep copies of your original consent, and of your withdrawal request.

What will happen if I decide to take part? You will be asked to interact with the tool and furthermore answer some questions regarding its usability and user experience.

Are there any risks associated with taking part? There are no significant risks associated with participation.

What will happen to the results of this study? The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a maximum of 4 years. All potentially identifiable data will be deleted within this timeframe if it has not already been deleted as part of anonymization.

Data protection and confidentiality. Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number rather than by name. Your data will only be viewed by the researcher/research team: Zofia Kniter and James Garforth. All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint).

Participant Information Sheet (page 2)

What are my data protection rights? The University of Edinburgh is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

Who can I contact?If you have any further questions about the study, please contact the lead researcher, Zofia Kniter, s2094204@ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

Updated information. If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.in-f.ed.ac.uk/infweb/research/study-updates.

Alternative formats. To request this document in an alternative format, such as large print or on coloured paper, please contact me at s2094204@ed.ac.uk

General information. For general information about how we use your data, go to: edin.ac/privacy-research

Participant Consent Form

Project title: Testing of the Ethics Tool
Principal investigator: James Garforth
Researcher collecting data: Zofia Kniter
PI contact details: james.garforth@ed.ac.uk

By participating in the study you agree that:

1. I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.

2. My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.

3. I consent to my anonymised data being used in academic publications and presentations.

4. I understand that my data will be stored for the duration outlined in the Participant Information Sheet.

1. Please enter your name *

2. I agree to take part in this study *

- ◯ Yes
- ◯ No

Appendix J

Evaluation of the high-fidelity prototype

J.1 Evaluation with Experts

J.1.1 Thinking aloud tasks

- Propose a new activity
- Propose a new ethics topic
- View activities and find and choose an activity of interest and find courses which cover this activity
- Find a course you deliver or used to deliver and after viewing it find information on degrees which require this course and activities which it covers
- Go to the CS and maths degree and in the Table view find all compulsory courses which cover the topics of Fairness
- See a heatmap view for BSc computer science and find the number of courses delivered in Year 2 semester 1 on Privacy and find the names of these courses, are they compulsory?
- Go to Artificial intelligence and find recommendations for the degree. Which topics are missing?
- Which topics are covered by at least one compulsory course and how many courses cover these? View these courses

J.1.2 Final questions

- On scale from 1-5 how easy was the tool to use?
- On a scale from 1-5 how appropriate was the choice of displayed information in the curriculum maps?
- On a scale from 1-5 how useful is the tool?
- Ona scale from 1-5 what rating would you give overall?

- Which feature did you like the most?
- What suggestions do you have for improvements?

J.2 System Usability Scale

J.2.1 SUS Formula

This is the formula that was used when calculating the SUS scores for each participant [49].

- Subtract 1 from each score given to all odd questions
- Subtract each score given to all even questions from 5
- Sum all obtained contributions
- Multiply the sum by 2.5

J.2.2 SUS Questionnaire

System Usability Scale (SUS)

* Required

1. I agree to take part in this study *

- ◯ Yes
- ◯ No

2. Question *

	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
I think that I would like to use this website frequently	◯	◯	◯	◯	◯
I found the system unnecessarily complex.	◯	◯	◯	◯	◯
I thought the system was easy to use.	◯	◯	◯	◯	◯
I think that I would need the support of a technical person to be able to use this system.	◯	◯	◯	◯	◯
I found the various functions in this system were well integrated.	◯	◯	◯	◯	◯
I thought there was too much inconsistency in this system.	◯	◯	◯	◯	◯
I would imagine that most people would learn to use this system very quickly.	◯	◯	◯	◯	◯
I found the system very cumbersome to use.	◯	◯	◯	◯	◯
I felt very confident using the system.	◯	◯	◯	◯	◯
I needed to learn a lot of things before I could get going with this system.	◯	◯	◯	◯	◯

3. Which curriculum map (the section for degrees) did you find easiest to use?

4. Did you find the information on the website understandable?

5. Which features did you like the most/found most useful?

6. What are your suggestions for future improvements?