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Applying Science Fiction to Course Design

- A case of computer science

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Abstract

Entry-level technical and scientific courses are provided for both tech and non-tech students in universities. Currently, the teaching materials used in these courses are mainly academic papers and real business cases. Learning with only formal materials that are full of terminologies is lacking pleasure and challenging for entry-level students. Previous studies also show that teaching technology and science with science fiction (SF) could have many benefits, including can successfully engage students (Vrasidas *et al.*, 2015), let students remember knowledge a longer time (Negrete & Lartigue, 2010), and brings up discussions about ethics (Burton, Goldsmith & Mattei, 2015). However, a study focuses on teaching computer science with SF materials is lacking. This study focuses on applying SF to teaching computer science.

A case study is conducted. An SF video: *Hated in the Nation* is selected as additional teaching material for the course *Introduction to Artificial Intelligence*. Students who enrolled in the course voluntarily join the research. A questionnaire and an open question are used for data gathering. Both the students' answers to the questionnaire and to the open questions are analysed to answer the research questions: 1) What are the attitudes of students to using SF in teaching AI? 2) How does watching the SF stories *Hated in the Nation* support students in learning AI at entry level?

The results of the case study demonstrate that the benefits of including *Hated in the Nation* as an additional learning material can be summarized as three points: 1). making the learning process more interesting, 2) inspiring students from many perspectives, and 3) enhancing students' critical thinking. The main challenges of teaching with *Hated in the Nation* are: 1) learning with *Hated in the Nation* has a relatively low learning-time ratio, 2) *Hated in the Nation* contains exaggerating AI technology, 3) and explanation about AI technology is limited in *Hated in the Nation*.

Overall, the results of the study encourage educators using SFs to introduce technology concepts and science theories at entry level, and also using SFs to teach ethics related to technology and science development. Which needs to be clarified is that SFs should be used as additional materials to increase the diversity of teaching activities and increase learners' interests in learning. SFs are not a replacement of formal and traditional teaching materials.

Keywords: science fiction (SF), course design, learning motivation, artificial intelligence (AI), teaching material

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1. Introduction

1.1 Background

Currently, Aalto University provides many courses for students to gain big pictures of various advanced technologies, for both tech and non-tech students. For example, the course *ICT Enabled Service Business and Innovation*, organized by the Department of Computer Science, introduces hot topics in computer science, such as platform economy and blockchain technology; the course *Introduction to Analytics and Data Science* introduces what can be done with data in different fields, including medical treatment, architecture and climate forecasting. The teaching materials used in these lectures are mainly academic papers and real business cases. The problem is that the current teaching methods are not efficient or effective enough, as they are lacking the pleasure and require students to study with only formal materials. Even though lecturers have been trying to make the learning process more interesting by inviting guest lecturers to tell their business cases and increasing discussion sessions, the effect is small.

Technology is not easy to understand, and academic papers and lectures, which are full of terminologies, make the learning process even more challenging, especially for non-tech students. As one of the purposes of these lectures is to stimulate students' interests in advanced technologies and inspire them to continue to explore possible applications of those technologies and business opportunities, designing a more pleasant and interesting learning process for students is necessary.

Science fiction (SF) is a genre of literature that first appeared in the early 19th century, right between the first and the second industrial revolutions. In the beginning, science fiction was mainly for entertainment, but nowadays, hard science fictions become increasingly popular, in which scientific facts are significant components of the stories. Many science fiction writers are also scientists, and many science fictions have scientists as consultants (Stepney, 2015). For example, a study focused on Michael Crichton's science fiction novels shows that the novels do contain

actual scientific information. To make the process of learning technology and science more interesting, some scholars have been exploring the possibility of using SF in teaching technology and science. SF could be used for introducing science and technology, teaching reading and writing skills, as well as increasing critical thinking and analytical skills of students (Putt, 2011).

Previous studies also show that teaching technology and science has many benefits. For example, science fiction can successfully engage students (Vrasidas *et al.*, 2015), students remember knowledge learned from a science fiction novel longer time than knowledge learned from a factual list (Negrete & Lartigue, 2010), and SF brings up discussions about ethics (Burton, Goldsmith & Mattei, 2015).

1.2 Research questions and objectives

Though previous studies have proved that some SFs do contain legitimate science and technology topics and can be used for education in classrooms, a study that focuses on educating computer science with SF is still lacking. This research focuses on the topic of teaching artificial intelligence (AI) with SF. To narrow down the scope of the research, a case study is conducted. A course: *Introduction to Artificial Intelligence (IAI)*, and an SF video: *Hated in the Nation*, are selected for this case study. Students who are taking the course IAI voluntarily join the research. The student volunteers are required to watch *Hated in the Nation* and then answer both a questionnaire and an open question. The answers to the questionnaire and the open question are analyzed to answer the following research questions:

- What are the attitudes of students to using SF in teaching AI?
- How does watching the SF stories *Hated in the Nation* support students in learning AI at entry level?

The research objectives are:

- To find out students' attitudes to watching *Hated in the Nation* as a part of the course.

- To find out whether students would like to include some SF materials as learning materials in technical or scientific courses in general.
- To test whether the SF stories *Hated in the Nation* makes students more interested in AI.
- To test whether the SF stories *Hated in the Nation* stimulates reflection on artificial intelligence among students.
- To test whether the SF stories *Hated in the Nation* stimulates reflection on the ethics of AI among students.

1.3 Structure of the thesis

After the introduction chapter, the second chapter is the literature review. The literature review consists of three perspectives, general introduction to science fiction, theories in education, and previous studies in using science fiction in education. Then a theoretical framework is built based on the findings of the literature review. The theoretical framework consists of three parts, each part corresponds to one perspective of the literature review. In chapter 3, the research questions, design and methods of this study are presented. The theoretical perspectives of research methodologies are reviewed, and a suitable research methodology is adopted for this thesis. Then the process of the empirical research is introduced, including the research context, the data collection process and the data analysis method. Findings of the empirical research are presented in chapter 4. The results of this research are discussed in chapter 5. Chapter 6 concludes the thesis.

2. Theoretical background and analytical framework

2.1 Introduction to science fiction

In this subchapter, the general information about SF is introduced. First, the history of SF as literature is shortly presented, including the appearance and development of SF. And then, an interesting phenomenon of the effects of SF on the public's perceptions about technology and science is introduced. Finally, some previous studies about the relationship between SF and technology as well as science are found and discussed.

2.1.1 Science fiction as a genre of literature

SF is a genre of imaginative literature that typically dealing with plausible or fictional advance concepts of science and technology. SFs often try to explore the possibility of science and technology development. SF is dubbed as "the literature of ideas" (Gilks, Fleming & Allen, 2003).

The first science fiction, *Frankenstein*, was written in 1818, by Mary Shelley, which describes the tragedy of a scientist, called Frankenstein, and the monster he created (Shelley, 2016). At that time, many western countries accomplished the first industrial revolution, and the word "science" entered ordinary people's lives like never before. Human beings started to enjoy the benefits brought by science and technology. People also started to imagine what can be done with this kind of new power, and what kind of problems that new technology and science might bring up to their lives. Study of biology rose, and one of the hot topics was the boundary between life and death (Ruston, 2015). In the novel *Frankenstein*, Frankenstein dreamed to control life and death. He created a monster with bodies that he stole from a mortuary. However, Frankenstein did not prepare for a series of problems followed on. A cruel fight started between Frankenstein and the monster (Shelley, 2016).

Traditional science fiction can be divided into two genres, canon science fiction and

popular science fiction (Li, 2018). Canon science fiction tries to explore how new technology might affect our society. In canon science fiction, the attitude to new technology can be cautious, rejecting or embracing, but often they understand change is a must. Frankenstein is also a canon science fiction. Popular science fiction, in the beginning, was mainly for workers. Most of the workers were born in farming families, and only finished basic education, so popular science fictions were often easy to read. As industrialization developed, especially the paper and print industry, workers got more chances to enjoy reading. Till the end of the 19th century, in the US, science fiction built its own system as a new form of literature (Li, 2018). After the second world war, the golden age of science fiction started in the USA. Even though Americans had just experienced the Great Depression and the second world war, there were plenty of young readers becoming fans of science fiction. Writers even got ideas from the war, as the government had invested a great deal of money on developing military technology and new inventions during the war (Roberts, 2000). Since SFs are full of fresh ideas and imagination of technology, the empirical research of this study tests whether the selected SF *Hated in the Nation* inspires students' imagination about AI and gives them fresh ideas for writing their course essays.

2.1.2 Reasons of SF effects on perceptions about technology and science

Even though SFs are not for predicting the future, these stories do have a huge effect on the public and the culture of the society, and they will further affect many people's behaviours. Watching movies and TV shows are one of the main entertainments for many people nowadays. According to Roberts et al. (1999) as cited by Barnett et al. (2006:p.180): "the typical American, aged 10–22, spends an average of 3 h per week watching movies and 8 h per week watching television shows". Regarding the popularization of the Internet and personal computers, the number of hours that the public spends on watching movies and television shows is very likely to increase when comparing to 20 years before. And since SF is a popular genre of movies and television shows nowadays, it is very likely that typical citizens spend some time watching SF movies and television show every week.

SF television series and movies have significant cultural outputs to the public, and they will affect the public's opinion and cognition about science and technology. Depending on the contents, SFs might encourage high expectations, instil fears about science and technology, or develop stereotypes scientists. Evidence found in previous studies includes that viewers of *Crime Scene Investigation* had a higher expectation to the forensic science than non-viewers (Schweitzer & Saks, 2007), and SFs with the theme of cybercrime cause anxieties and fears about the Internet to the public (Wall, 2008). The gender bias that is shown in the field of physics and other hard sciences might be related to the fact that female characters seldom play important roles in SFs (Geelan, Prain & Hasse, 2015). Moreover, "knowledge of technology" and "science theories" in SFs, no matter plausible or not, are easier to remember. Barnett et al. (2006:p.188) found that "a single viewing of a popular science fiction film can have a great influence on student ideas and conceptual understanding of scientific concepts". In the study, a group of students completed an 8-week instruction on astronomy and earth science. And then they watched a 2-hour SF movie, *The Core*, which contains some information about the structure of the earth (Barnett et al., 2006). After that, when the students were asked some questions about the structure of the earth, the majority of the students referred back to the movie, even though sometimes the movie goes wrong (Barnett et al., 2006). Another study shows that students remember knowledge learned from a science fiction novel longer time than knowledge learned from a factual list (Negrete & Lartigue, 2010).

Through SF stories, audiences find those originally cold, uninteresting, complicated technologies and science theories becoming understandable, attractive, and relevant to their lives. SFs both influence and reflect the public's attitude to science and technology. "Learning the facts of science through science fiction learning resources also means learning the concerns of science. We invest emotions and feelings in the facts we learn. Science fiction helps people invest emotions into what may by many students with science anxiety be considered 'dry' and 'boring' facts. It can make them see a long-term purpose in engaging in science" (Geelan, Prain & Hasse,

2015:p.9). “A successor science inspired by science fiction could take this acknowledgement as a starting point acknowledging that teaching science is also teaching concerns and thus politics” (Geelan, Prain & Hasse, 2015:p.15). Many SFs that were written between the 1930s and the 1960s in the USA reflect that during that period, the public had a positive attitude to the technology and science, and believed that advanced technology and science would lead to better lives (Schmidt, 2010). “It has been argued that the entanglement between science fiction and science is mainly about either engaging students in a science they would otherwise find uninteresting or convincing the public to spend more money on a field of science they would otherwise find less important” (Geelan, Prain & Hasse, 2015:pp.16–17). For the above reason, this thesis will test whether watching the selected SF *Hated in the Nation* makes students more interested in AI.

2.1.3 Relationships between SF and technology as well as science

Many previous studies have discussed the topic of whether SF contains real technology and plausible science theories, and researchers have two different opinions. As shown below, some of the researchers believe that science fictions are mainly for entertainment and contains neither plausible technology nor science theories, while others find evidence that many high-quality hard science fictions do contains true or plausible technology and science theories. Wall (2008) studied the fear of cybercrime that SF has brought to the public. Many SFs with the theme of cybercrime actually exaggerate the power and effects of cybercrime compared to the real cybercrime, which has been reported in the real world. Many people get to know cybercrime mainly through the cybercrime SFs. That is the reason why the public feels unnecessary insecure and worry too much about the Internet environment. Wall (2008) points out that the excessive fear of the public will cause unnecessary resistance to technology development. Similarly, Schweitzer and Saks (2007) studied how popular fiction about forensic science affects the public’s expectation of real forensic science. According to the study, viewers of *Crime Scene Investigation*, a popular television play series about forensic science in the USA, had higher expectations on the forensic science than non-viewers. Schweitzer and Saks

(2007) point out that compared with the television series, *Crime Scene Investigation*, the power of the forensic science for investigating criminal cases is in practice very limited.

On the other hand, Kirsch (2012) analysing the scene from the technology perspective states that various kinds of cybercrime and even cyber warfare have become easy or possible to achieve today. In 2017, Estonia suffered a two-week-long cyber assault. The assault shut down banks, online newspapers, and government communications in the whole country (Kirsch, 2012). Theoretically, from the technology perspective, serious cybercrimes are possible to happen in any time, but neither the law in the USA nor any international treaty has mature regulations or be prepared with any kind of cybercrime (Kirsch, 2012). Thus, Kirsch (2012) argues that the government of the USA should bring out relevant regulations and laws in order to be prepared for dealing with cybercrime or even cyber warfare once they happen. From this perspective, those SFs with the theme of cybercrime actually remind both the public and countries to think about the possible Internet environment in the future and be prepared early before any damage happens. Schmidt (2010:p.1) discusses the idea of terraforming, how SF and science overlap and affect each other: "Early ideas about terraforming emerged from the 1930s-1960s hard science fiction. By the early twenty-first century, the idea of terraforming had been the subject of over two-hundred scientific journal articles and six different conferences sponsored by NASA and other agencies". The study finds that SF writers and scientists have inspired each other, and the idea of terraforming in SF and real science work have developed together (Schmidt, 2010). Another study focusing on Michael Crichton's science fiction novels shows that Michael Crichton's novels do contain actual scientific information (Putt, 2011). They could be used for coursework, such as teaching science, reading, and writing, as well as critical thinking and analytical skills (Putt, 2011). Arthur C. Clarke's idea of meson reaction in *The Sands of Mars* was still founded on scientific law (Schmidt, 2010). The fact is that many science fiction writers are also scientists, and many science fictions have scientists as consultants (Stepney, 2015), so it is not surprising that many high-quality SFs contain true or plausible technologies and scientific theories.

As a genre of literature, SF contains a huge number of literary works, with various themes, qualities, and purposes. No matter what opinions the researchers hold, they can find evidence to support their opinions. Science fiction can be divided into two branches: hard science fiction and soft science fiction. Hard science fiction is a category of science fiction characterized by an emphasis on scientific accuracy, while soft SF focuses more on social sciences, philosophy, and humanity. If soft SF does not contain technology or hard science subjects, it does not mean hard SF also does not contain technology or science information. Similarly, if some hard SFs contain only wrong information about technology and science, it does not mean all other hard SFs do not contain any correct information about technology and science. That is the reason why for using SF as a kind of informal teaching materials, educators need to select those high-quality hard SFs and also identify the true technology and plausible science theories in the SFs.

Even though currently many people are not familiar with the idea of combining science fiction with real technology and science theories, this idea actually already has a long history. *Amazing Stories* was the first science fiction magazine, which was first published in 1926, and Hugo Gernsback was the first publisher of the magazine. “Hugo Gernsback defines science fiction as ‘a charming romance intermingled with scientific fact and prophetic vision’. Gernsback repeatedly called on writers to do research in order to utilize up-to-date scientific knowledge and ideas to include in their stories and build their plots around, suggesting an ideal story would contain seventy-five per cent literature and twenty-five per cent science” (Schmidt, 2010:p.2).

Some famous hard science fictions in recent years include *Interstellar*, a movie directed by Christopher Jonathan James Nolan, *The Three-body Problem*, a novel written by Cixin Liu, and *Black Mirror*, a television series created by Charlie Brooker. According to Noletto (2018), the rise of hard science fiction is highly correlated with the age of its technology reproducibility. The technology reproducibility means a creation could be perfectly reproduced, and the reproductions have the same value as the original creation, for example, the books produced by pressing and the movies

played in cinemas. On the contrary, a unique original creation, which cannot be replaced by other reproduction is an aura, for example, a painting by Pablo Picasso. A huge number of technology reproductions started to appear in the second industrial revolution. The appearance of printing technology not only allows more public to access reading materials but also allows more readers to become writers since the demand for literature increased (Noletto, 2018). The gap between readers and writers is minimized (Noletto, 2018). Because of that, readers became “more demanding, wishful of more complex ideas, more plausible theories and believable (im)possibilities” (Noletto, 2018:p.173). The subgenre - hard SF - rose since then (Noletto, 2018). At the age of the Internet, writing and spreading information becomes incredibly easy; massive affordable electronic products appear in the market even allowing masses to produce and publish videos and movies. Theoretically, today, because producing and publishing creation become increasingly easier, the audiences expect to see increasingly higher quality hard science fiction with more plausible scientific theories, and the quality of hard science fictions in the market are supposed to be better than any other time before.

Nowadays, some scholars use SF as a tool to discuss the potential effects of science and technology, as well as the possibilities of our future. In 2011, Brian David Johnson published his book *Science Fiction Prototyping: Designing the Future with Science Fiction*, in which he introduced a new method for imaging the possibilities of the future. Johnson suggested: “The main (but not exclusive) methodology is the use of science-fiction stories, grounded in existing practice which are written for the explicit purpose of acting as prototypes for people to explore a wide variety of futures. These 'science fiction prototypes' (SCIENCE FICTIONS) can be created by scientists, engineers, business or socio-political professionals to stretch their work or, for example, by writers, film/stage directors, school children and members of the public to influence the work of professionals. In this way, these stories act as a way of involving the widest section of the population to help set the research agenda” (Johnson, 2011:p.19). *Nature*, as a famous science journal has also its science fiction section -- *Futures*. Each article in *Futures* is an entirely fictional, self-contained story of around 850–950 words in length. The genre of the articles is 'hard' (that is,

'scientific') SF. *Futures* also links relevant technology and science news to each SF story. Copenhagen Institute for Future Studies (CIFS) is a non-profit global research organization, which provides strategic consulting services to corporations and organizations. CIFS has a magazine called *Award-winning SCENARIO Magazine*, which is published six times a year. The magazine is developed and edited at CIFS in collaboration with writers, scientists, thinkers, and creative minds from around the world. SCENARIO uses the form of fiction to reveal to readers unprecedented insights into trends, zeitgeist, scientific breakthroughs, and new patterns of behaviour that may shape our future society. The target audience of the magazine is professionals and decision-makers, and the mission and the ambition of the magazine are to inspire the readers to take action based on independent research and an unbiased perspective on the future.

The future is uncertain and cannot be predicted, but SF can be used to vision and explore possible futures. The development of society and the prediction of the future can be seen as a bipolar disorder system, which means the development of the society and the prediction of the future are effects to each other (Harari, 2016). How society is developing in the past and now affects how we predict the future, and how we predict the future affects how society develops in the future. For example, the fast development of the Internet and IT industry make many people concern about the personal privacy issues in the future, sociologists might predict that the society will face serious personal privacy problem in the future. However, if we take this prediction seriously, we might pay more attention to a personal privacy protected system, so the predicted personal privacy problem might never happen. SFs tell stories about the possible future and bring out the possible problems that might happen in the future. From this perspective, SFs do not only entertain the audiences, but also remain them to think about what technology might bring to our lives.

Overall, according to previous studies, SF as a genre of literature contains a huge number of works with various quality and focusing points. Some of SFs contain legitimate technologies and scientific theories, while some others do not contain true technologies or scientific theories, or many SFs contain both true and fictional

technologies and scientific theories. That is the reason why, before using SF as a kind of informal teaching materials, educators need to select high-quality hard SFs and also to identify the true technology and plausible scientific theories in the SFs. Besides, even researchers holding different opinions on whether SFs contain true or plausible technology and scientific theories, many of them agree that SFs have a significant impact on how the public perceive technology. Barnett et al. (2006) suggest that SF television plays and movies should be brought to the school for science education, even though they hold the opinion that many SFs contain misleading information on science. In their own words, "Science fiction films have the capacity to capture the attention and imagination of students and research has shown that the general public's interest in science often increases when exposed to science on television and on film. Therefore, rather than avoiding showing SF films in schools, it may be a better strategy to engage students in the critique of science fiction films" (Barnett et al., 2006:p.190). For the reason above, the empirical research of this study carefully selected a high-quality SF story *Hated in the Nation*, which is highly relevant to the course IAI and contains plausible AI technologies and theories.

2.2 Theories in education

In this subchapter, theories in education are introduced. To understand how learners could benefit from learning with SF, knowing the learning process is fundamental. In the following, education theories are presented from three perspectives: the learning motivation theories, the learning theories, and the storytelling technique in education.

2.2.1 Learning motivation theories

In order to better understand the purpose of this study, this section reviews two of well-developed motivation theories, which could stand alone and contribute to the education domain (Gopalan *et al.*, 2017)). These two theories are the intrinsic and extrinsic motivation theory of the self-determination theory, and the Attention,

Relevance, Confidence and Satisfaction (ARCS) model. According to Ryan and Deci (2000), the classic intrinsic and extrinsic motivation theory divides motivation into two main types. As the name of the theory, the two types of motivations are intrinsic motivation and extrinsic motivation. Ryan and Deci then further classify the extrinsic motivation into four subtypes according to their autonomous level. From a low autonomous level to a high autonomous level, the four subtypes of extrinsic motivation are: external regulation, introjection, identification, and integration. To have an overall understanding of the classic intrinsic and extrinsic motivation theory, the definitions of intrinsic motivation and extrinsic motivation are introduced in the following. However, the four subtypes extrinsic motivations will not be discussed in detail, since classifying the type of motivation is not the focusing point of this study.

In the context of education, intrinsic motivation is the enjoyment that learners gain from the learning process itself. In other words, if the nature of the learning process is interesting, a learner will have high intrinsic motivation. "Intrinsic motivation remains an important construct, reflecting the natural human propensity to learn and assimilate" (Ryan & Deci, 2000:p.1). Extrinsic motivation depends on stimulation from the outside environment, rather than from the learning activities themselves, for example, rules and regulation of schools, or punishment and reward from parents. In other words, if a student studies a subject, not because of the satisfaction he/she can gain from the learning activity, but other outcomes he/she will gain, which could be a good grade, some rewards, or a dream job, those are extrinsic motivation because he/she is doing the work in order to attain the separable outcomes. "Extrinsic motivation is argued to vary considerably in its relative autonomy and thus can either reflect external control or true self-regulation" (Ryan & Deci, 2000:p.1). High relative autonomy means students have the freedom to decide what to learn and involve in learning activities because of their own willingness. For example, if a student improves his programming skills because he wants to be a programmer in the future, his extrinsic motivation is associated with high relative autonomy, so it reflects true self-regulation. On the contrary, if a student studies a subject because of the fear of failure of the final exam, then the extrinsic motivation, in this case, has low relative autonomy, and thus reflects external control. More autonomous

extrinsic motivation leads to better academics performance, such as greater engagement, less dropping out, higher quality learning and greater psychological well-being. Because many tasks students get in school are not inherently enjoyable, promoting more active and volitional forms of extrinsic motivation is a smart teaching strategy (Ryan & Deci, 2000).

The ARCS model of motivation was originally proposed by Keller in the year 1984. According to Keller (2000), the ARCS model consists of four components: Attention, Relevance, Confidence, and Satisfaction. “Attention” refers to the learners’ interest. It is critical to get and hold the learners’ interests and attention. “Relevance” means that the learning process should show the usefulness of the learning content so that learners can connect the knowledge with the real world. The “Confidence” component emphasises the importance of developing success expectation among learners. A learner with a success expectation shows better ability to control their learning processes. There is a correlation between confidence level and success expectation. That’s why providing estimation of the probability of the success to learners is important. The “Satisfaction” focuses on making learners satisfied with what they achieved during the learning process. An interesting finding is as shown in Figure 1, as motivation increases, performance first increases to an optimal point, then decreases. When “motivation increases to levels where excessive stress leads to performance decrements” (Keller, 2000:p.5).

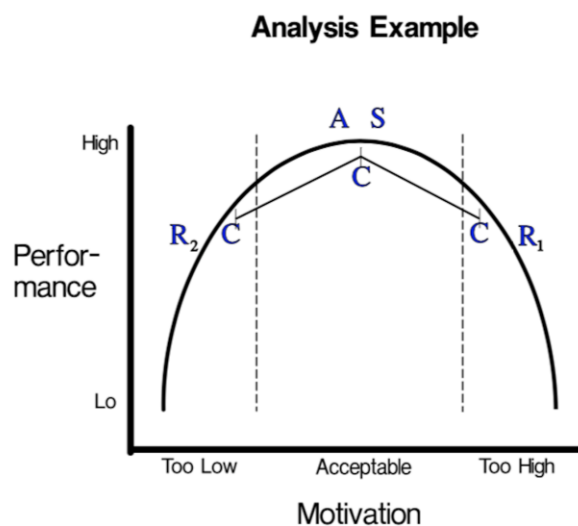


Figure 1. Curvilinear diagram for audience analysis (Keller, 2000:p.7).

Comparing the intrinsic and extrinsic theory, and the ARCS model of motivation, the attention component in the ARCS model of motivation is related to the intrinsic motivation, while the relevance, confidence, satisfaction components are related to extrinsic motivation. Keller (1987) further gave strategies to use each component for instructional design. In short, the attention strategies include incongruity and conflict, concreteness, variability, humour, inquiry, as well as participation (Keller, 1987). All of these strategies are intended to make a lecture more interesting, in other words, to make the learning process itself more interesting and enjoyable. For example, as one of the attention strategies, variability is further explained that varying the medium for instruction, such as films, videos, and prints, could be used to increase the variability. Comparing to only using text materials for teaching, introducing some informal materials will often make the lecture more attracted. Thus, the attention component of the ARCS model mainly tends to increase learners' intrinsic motivation. The relevance strategies include experience, present worth, future usefulness, need matching, modelling, and choice (Keller, 1987). The relevance strategies try to spot out the value and meaning of acquiring specific knowledge, how the knowledge could be useful for the learners, for the society in the past, at present, or in the future. The confidence strategies include learning requirements, difficulty, expectations, attributions, and self-confidence (Keller, 1987). The confidence strategies aim at designing a proper study outcome for students, which should be balanced with the study efforts. The satisfaction strategies include natural consequences, unexpected reward, positive outcomes, avoiding negative influences, and scheduling (Keller, 1987). Satisfaction strategies emphasise that teachers should give rewards or positive stimulation timely after students accomplish tasks, in order to increase students' satisfaction with the learning activities. Hence, it is obvious that the relevance, confidence, satisfaction components are related to stimulation from the environment, in other words, extrinsic motivation.

The discussion above shows that the intrinsic and extrinsic motivation theory and the ARCS model of motivation are actually relevant and support each other. Both

theories propose that learning motivation depends on both the experience of the learning process itself and the stimulation from the learning environment. In addition, both theories value the importance of seeking the meaning behind learning activities and emotional attachment in motivating learning.

Theoretically, learning with SF could increase both intrinsic and extrinsic motivation of students. SFs are originally created for entertainment. Watching SFs as part of the learning process is fun. If students enjoy the learning process itself rather than aiming at other outcomes from learning, that is intrinsic motivation. Besides, SFs connect technologies and science with life, explore meanings and attach emotion to technologies and science. Finding meanings behind the learning activities is one important element for increasing learners' extrinsic learning motivation. In the empirical research of this study, students are asked questions related to intrinsic motivation, such as whether they enjoy watching the selected SF? And whether they are more interested in AI in general after watching the selected SF? In the ARCS model of motivation, these questions are related to the attention component. Questions related to extrinsic motivation are also included, for example, whether watching the selected SF help them think critically about the ethics of AI? In the ARCS model of motivation, such a question is related to the relevant component.

2.2.2 Learning theories

Learning theories study how people absorb, process, and retain knowledge during learning, and identify significant elements of the learning process. For educators, in order to design a suitable instruction strategy, and serve the learner better, it is essential to understand how humans learn. This section reviews two learning theories which have been widely tested, used and accepted in the field of education.

According to Bada (2015), the main idea of constructivism is that learning is a constructive process, which is highly involving with the previous knowledge and experience of a learner. Constructivism is based on the premise that cognition is the result of a subjective 'mental construction'. In other words, the learning theory of

constructivism emphasizes that a learner plays an active role in his/her learning process to constantly reconstruct his/her knowledge framework and fill in detail into the framework in his/her mind. Constructivists believe that knowledge cannot be simply transmitted from teachers to students because students do not learn deeply in passive ways, such as listening in classroom and reading textbook. Therefore, constructivism promotes students' free exploration and autonomy within a given framework, and education should invest more in cultivating a learner's curiosity. Constructivism sees the role of a teacher as a facilitator, who focuses more on students, and will give a help-hand when the students have problems in their learning process. Since constructivism believes that students play an active role in learning, the main task of teachers is to motivate students (Bada, 2015).

The transformative learning theory has been a growing area of study of adult learning and has significant implications for the practice of teaching adults. Transformative learning theory focuses on the often-necessary change required in a learner's preconceptions and worldview. "There is an instinctive drive among all humans to make meaning of their daily lives" (Taylor, 2008:p.5). Taylor (2008) argues that all the learning activities at certain level share the same goal to understand the world better and construct a better worldview in order to guide future reactions. Overall, "transformative learning is first and foremost about educating from a particular worldview" (Taylor, 2008:p.13)

Both the constructivism and the transformative learning theory emphasize the role of individuals in learning. Knowledge is often perceived as objective, and traditional teaching methods try to transmit exact existing knowledge to learners. However, the two learning theories introduce above totally revert the tradition recognition about learning and teaching. In the theory of constructivism, knowledge cannot be simply transmitted from teachers to students, but the students must be initiated in gaining knowledge. And the transformative learning theory allows learners to select and transform knowledge according to their proposes and precious experiences to construct their own worldview. Learning is seen as an individual and subjective process. The importance of learning motivation is emphasized in the learning

theories. Again, to increase learning motivation, making the learning process interesting and help learners find the meaning behind the learning activities are very important.

2.2.3 Role of storytelling in teaching

Storytelling is a process that people share and reflect on their experiences. Human life roots in the narrative. People construct their lives and shape the world we live in according to the tradition and memories written in stories. Though people have different cultural backgrounds and come from different generations, a story may be their common language. Learning in a social context is a very effective way, which lets the learner understand how knowledge could be applied in the real world. A story is where we combine knowledge with the social context. A story could be used to teach ethics, values and culture (Davidson, 2004).

Storytelling as a teaching method is effective. Learning with stories makes students more engaged. While learners have high engagement, they are able to associate the knowledge with new perspectives, and this is a process that learner absorbs the knowledge (Rossiter, 2002). A study proves that, through storytelling, the storyteller and listeners are able to build a long-lasting personal connection, improve the ability of problem-solving, and foster a shared understanding of their common goal (Denning, 2001). Further, listening to a storyteller is also a process for a child to learn respect (Archibald, 2008).

In indigenous communities, storytelling is a traditional tool for educating the younger generation their tradition, culture, and identity. In Eder's (2007) study, an indigenous community "Navajos" is interviewed. The interviewees are asked, regarding storytelling in practice, what kinds of traditions do they have? And what kinds of changes they would like to see in the future? Navajos tell that stories have significant effects on their children, and storytelling is their way to transfer the knowledge and principles of how to have a good life to the young generation. In indigenous communities, their knowledge and tradition are written in stories and passed to

every generation. Besides, storytelling in practice also lets storytellers form their own ideas from their previous experiences (Eder, 2007).

Recent studies show that using stories in adult education brings many benefits. For example, according to Haigh and Hardy (2010), the healthcare industry has a long tradition in using storytelling to engage service users and transmit health messages. Good stories used for education in the healthcare industry should both provide medical information and promote peer discussion within the group. In practice, using stories with elder patients can generate trust between patients and nurses, and it is easier for patients to accept the information provided through storytelling rather than written information. The effectiveness of storytelling also depends on culture. People who live in a culture that has a strong storytelling tradition will be more likely to accept that knowledge transmits through stories. Moreover, Akyeampong (2018) has used stories as a tool to help first-year-college students to gain the big picture of university life. Akyeampong points out that through writing stories, students become more engaged in the learning process, and writing stories also help students develop critical thinking and creativity (Akyeampong, 2018).

2.3 Previous studies in using science fiction in education

This subchapter, first, discusses the benefits and challenges of using SFs in education based on previous studies. Then a short introduction to previous cases of teaching with SFs follows. Finally, two concrete examples of how lecturers have used SFs in their courses are presented. SFs materials mentioned in this subchapter that are used as teaching and learning materials include television series, movies and novels.

2.3.1 Benefits and challenges of using SFs in education

Previous studies show that including SFs as teaching and learning material can bring many benefits to the classroom. First, SF adds interest to science and technology learning (Vrasidas *et al.*, 2015; Laprise & Winrich, 2010; Cavanaugh & Cavanaugh, 1996; Laprise & Winrich, 2010), enhances student engagement by putting technology

and science in context and providing materials for discussion (Cavanaugh & Cavanaugh, 1996; Vrasidas *et al.*, 2015; Bixler, 2007), and increases learning motivation (Vrasidas *et al.*, 2015; Laprise & Winrich, 2010; Ontell, 1997). Laprise and Winrich (2010:pp.48–49) note “Our data, collected by surveying students over two semesters, suggests that our goals of stimulating student interest in, and contemplation of, science were indeed met. Thus, the use of science fiction films can be a useful pedagogical tool for motivating non-science majors, with a greater effect noticed for specific course material than for science in general” Vrasidas *et al.* (2015:p.9) add: “Science fiction has great potential as a learning tool in science teaching and learning which can enhance student motivation and engagement in interdisciplinary”. Bixler (2007:p.339) confirms: “I felt their debate about the mode of change depicted in this short story was vigorous and insightful—what every instructor dreams of. In conclusion, such science fiction works as are suggested here can provide a wealth of ideas, discussions, and assignments for the biology classroom, ultimately leading to a more active role for students in learning about the theory of evolution”. According to Dubeck, Moshier and Bos, as cited by Cavanaugh and Cavanaugh (1996:p.4): "Using science films and literature to teach science can motivate a far broader spectrum of students in science than can be motivated by traditional methods".

In addition, a student remembers knowledge learnt from SFs longer time than knowledge learnt from formal and traditional learning materials. Negrete and Lartigue (2010:p.104) write: "The results of the studies performed with the RIRC method as a whole suggest that science can be learned through literary stories. In particular, they suggest that narrative information is retained for lengthier periods than factual information and that narratives constitute an important means for science communication to transmit information in an accurate, memorable and enjoyable way".

And finally, using SFs for teaching enhances critical thinking of learners (Burton, Goldsmith & Mattei, 2015; Bixler, 2007). Burton *et al.* (2015) discuss that educators often introduce the positive side of new technology and encourage students to

imagine the benefits that technology might bring to us in the future, but relatively seldom talk about the problem it might bring to us. Burton et al. use SFs to help students think critically about new technology. Bixler (2007:p.337) recommends using science fiction to confront students' "misconceptions about biology and encourage higher-level thinking (application, evaluation) about some of the more complicated issues in evolutionary theory".

Challenges of including SFs as teaching and learning materials have also been identified in previous studies. First, SFs are currently not a part of the curriculum as claimed by Vrasidas *et al.* (2015:p.12): "It requires extra effort and creativity from the part of the teachers to find ways to integrate scifi (science fiction) texts in their everyday teaching". Second, many SFs contain misleading information since they are not originally produced for teaching, so lecturers should carefully select SFs materials (Vrasidas *et al.*, 2015; Putt, 2011; Barnett *et al.*, 2006; Ontell, 1997). As has been discussed in the previous subchapter 2.1, SF as a genre of literature contains a great number of works, with various purpose and quality. "Sturgeon's law really applies here; the number of really bad books is extremely high in this format. For every well-done version like *Fantastic Voyage* by Isac Asimov or George Lucas' *Star Wars*, there are a lot of awful rip-offs" (Ontell, 1997:p.13). Furthermore, most of SFs often contains both true and fictional scientific information at the same time. Even the most high-quality hard SF contains fictional scientific information in order to serve the development of stories. Putt (2011:p.30) writes: "Teachers must take it upon themselves to analyze science fiction texts to determine whether the information is factual". Since scientific information in SFs is usually very convincing, identifying wrong information is extremely important for using SFs in lectures. As cited by Barnett et al. (2006:p.30): "Helga Nowotny (2005), the chair of the European Research Advisory Board, who noted that the past few years have seen an increasing proliferation of images and symbols via high-tech-driven media entertainment that is deliberately designed and intended to meet the public imagination about science, but often creates misunderstandings" regarding the nature of science and leads to a blurring between fact and fiction. Fourth, scientific information in SFs is often unorganized as observed by Negrete and Lartigue (2010:p.100): "Stories in the

present research are used as tools for communicating scientific information to individuals, not as tools for organising information provided by an individual". Lecturers may need to reorganize relative scenes or write a short version of the SFs stories in order to use those SFs on their lectures. On the other hand, lecturers can also ask students to identify and reorganize the relative scene in a film to explain specific science theories or technology principles.

2.3.2 Applications

SFs are used to introduce science theories, technology principles and ethics for students in different learning levels. The EU project "Science Fiction in Education" (SciFiEd) incorporated SFs in science teaching in primary schools in 5 countries (Vrasidas *et al.*, 2015). "In the spring of 2013 the course *Interim Topics in Computer Science: Science Fiction and Computer Ethics*, was offered at the University of Kentucky" (Burton, Goldsmith & Mattei, 2015:p.36). Burton, Goldsmith and Mattei (2015:p.33) state: "explore the use of science fiction as an appropriate tool to enable AI researchers to help engage students and the public on the current state and potential impacts of AI". In order to "engage students and encourage greater enthusiasm and interest in science", Cavanaugh (1996:p.3) uses science fiction films to introduce the study of space travel and the structure of cells, and also use SFs as a basis of interdisciplinary activities. Bixler (2007) have taught biology with SF short stories, books, and videos to spark useful ideas for one-time lectures, discussions, or assignments at Clark University. Barnett and Kafka (2007) teach their science sequence course at Boston College with SFs, and the topics include astronomy, ecology, environmental science, and physics. Laprise and Winrich (2010) use SF films to teach his biology course for non-science major students. Science fiction films serve as "a pedagogical tool to motivate student interest in science and to reinforce critical thinking about scientific concepts" (Laprise & Winrich, 2010:p.45). SFs are also used to teach language and writing skills (Ontell, 1997). However, this is not in the scope of this research. This research only focuses on teaching science theory and technology with SFs.

2.3.3 Examples

In this section, to let the readers have clear ideas of how SFs could be applied to teaching, two representative examples of using SFs in teaching are concretely described (Table 1). However, lecturers incorporate SFs in their lectures in many different ways.

Table 1. Two examples of using SF materials in teaching.

Example 1 (Bixler, 2007)	
Subject	Depictions of the Theory of Evolution in Science Fiction (biology course)
Target learner	Students at university
Purpose:	To introduce the concept of speciation
Movie	<i>The Time Machine</i>
Process	<p>> Introducing “species concepts (at least the biological and morphological species concepts), the reproductive isolating mechanisms that keep species distinct, and modes of speciation (allopatric and sympatric)” (Bixler, 2007:p.338).</p> <p>> Using “the novel to drive home these points” by “introduce the pertinent plot details (such as the following) orally or in a handout” (Bixler, 2007:p.338).</p> <p><i>“In ‘The Time Machine’, H .G. Wells’ hero travels 800,000 years into the future and encounters two very different populations of human descendants. One group is the Eloi, described as small, pretty, and child-like in appearance, fun-loving, and stupid in disposition. The Eloi frolic aboveground by day, eat flowers, and have sex frequently. The other</i></p>

	<p><i>population is the Morlocks, who are larger creatures that look somewhat like scary white apes. They are more intelligent than Eloi, and live underground, where they run some mysterious kind of machinery. They sometimes come aboveground at night to catch their prey. Morlocks eat Eloi”</i> (Bixler, 2007:p.338)</p> <p>> “Students form small groups and discuss questions like the ones below” (Bixler, 2007:p.338).</p> <p><i>“Assuming that Eloi and Morlocks are separate species, name and explain three prezygotic reproductive isolating mechanisms that might keep Morlocks and Eloi from interbreeding”</i> (Bixler, 2007:p.338)).</p> <p>> Explain suggested answers</p> <p><i>“I argue that the two groups are isolated by</i></p> <ul style="list-style-type: none"> <i>• habitat—Eloi aboveground, Morlocks below</i> <i>• time—Eloi are diurnal, Morlocks nocturnal</i> <i>• behaviour—one eats the other, so they are unlikely to perceive each other as mates; also, the differences in their intelligence and activities could isolate them</i> <i>• mechanical—although we cannot be certain, there may be enough of a size difference that Morlocks cannot mate with Eloi”</i> (Bixler, 2007:p.338).
Results	<p>> Students’ “debate about the mode of change depicted in this short story was vigorous and insightful” (Bixler, 2007:p.339).</p> <p>> The science fiction story provided “a wealth of ideas,</p>

	discussions, and assignments for the biology classroom, ultimately leading to a more active role for students in learning about the theory of evolution” (Bixler, 2007:p.339).
Example 2 (Laprise & Winrich, 2010)	
Subject	Natural Disasters
Target learner	Non-science major students at Babson College
Purpose:	To generally incorporate ethical and societal issues in addition to scientific and technological fundamentals.
Topic	Lecture 1: Asteroid impact, impact prevention; Lecture 2: Volcanic magma types, volcanic eruption effects; Lecture 3: Asteroid impact; Lecture 4: Climate change, cyclonic storms; Lecture 5: Hurricanes, midlatitude cyclones, wind-driven water waves; Lecture 6: Thunderstorms, tornadogenesis
Movie	Lecture 1: Armageddon; Lecture 2: Dante’s Peak; Lecture 3: Deep Impact; Lecture 4: Solyent Green; Lecture 5: The Day After Tomorrow The Perfect Storm Tornado; Lecture 6: Twister
Process	> “Students obtained and watched the films on their own time” (Laprise & Winrich, 2010:p.47). > “Students were required to view and critique films for

	<p>scientific accuracy in written work ... whether as a formal paper or as part of written exam questions and lab reports” (Laprise & Winrich, 2010:p.47).</p> <p>>“Students wrote a capstone paper critiquing the accuracy of science fiction films”. “Students were asked to review one film of their choice (following instructor approval) addressing the following points: (1) describe how the disaster was incorporated into the plot of the film; (2) give specific examples of how the disaster in the film was depicted in a realistic manner; and (3) give specific examples of how the disaster in the film was depicted in an unrealistic manner and suggest how those instances might be changed to make the disaster more realistic”. “The films were not discussed in class” (Laprise & Winrich, 2010:p.47).</p>
<p>Expecting Results</p>	<p>“Our goals for the use of these films were (1) to excite the interest of students in our courses, specially, and (2) to get students thinking about the broader implications of science information, and misinformation depicted through the films (Laprise & Winrich, 2010:p.46)”.</p> <p>“Our main objective was to foster curiosity and respect for the sciences by encouraging analyses of science fact versus science fiction portrayed in popular culture (Laprise & Winrich, 2010:p.46)”.</p>

2.4 Framework of the study

In this subchapter, the main findings from the literature review are synthesized. A theoretical framework is built based on the findings, which consists of three parts.

Each part of the framework is shown separately in Figure 2, Figure 3, and Figure 4. This subchapter also explains the contents of the framework.

The literature review of this study is conducted from three perspectives: introduction to SF, theories in education, and previous studies in using SF in education. SF as a genre of literature offers the most attractive, unique and incredible stories related to technology and science. Thus, teaching with SFs could add interests to teaching activities. However, SFs contains both true/plausible and fictional theories of technology and science. Lectures should carefully select valuable SFs materials for educational purposes. The appearance of SF is in the early of the 19th century, right between the first and the second industrial revolution. After more than 100 years of development, in the middle of the 20th century, the golden age of SF starts in American. During the second world war, scientific research had big progress, new technologies were developed, and new weapons were invented. SF writers got fresh ideas from the development of science and technologies. SF has a huge effect on the public's perception of science and technology. SF television series and movies are popular. And SF connects technology and science to our lives, so the audiences are more concerned and interested in science and technology. However, SF is originally produced for entertainment, rather than educating science and technology knowledge. SF contains both true/plausible and misleading information. The quality of SF vary. A good quality hard SF could contain many true/plausible science and technology knowledge, while a soft SF focuses more on culture, history and philosophy and has limited information about technology and science, or some bad quality SF has mainly misleading information. In many cases, one SF story can have both true and wrong science theories and technology principles. SF is also a tool for researchers to imagine the possibility of future society. Today, many institutions have been using SF as a tool for future studies. Evidence is found from the history, SF and development of science and technology affect each other.

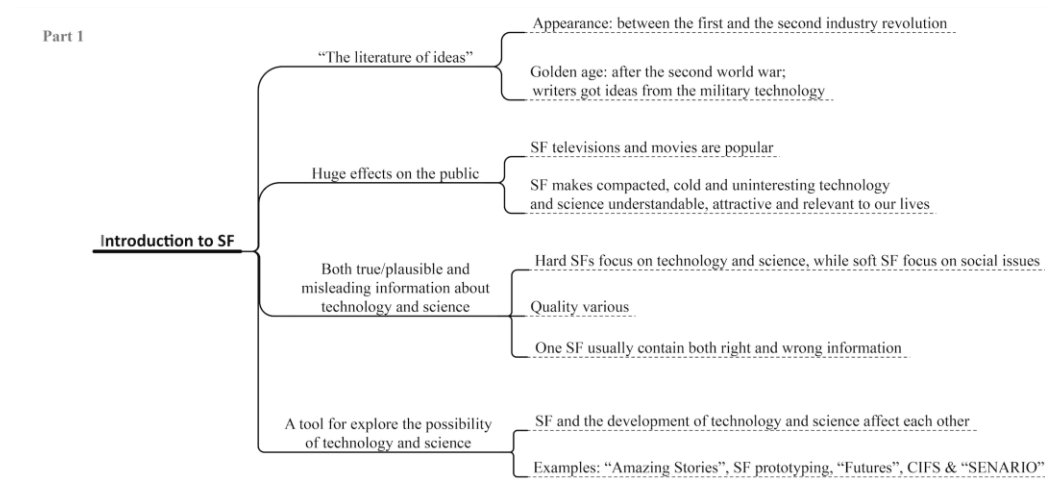


Figure 2. Introduction to SF.

In the second part, theories in education are reviewed, including motivation theories, learning theories, and the storytelling technique in education. Adding interests to the learning process, and attaching meaning to learners’ learning behaviours are two significant perspectives for learners to achieve good learning outcomes. Two motivation theories are reviewed: the intrinsic and extrinsic motivation theory, as well as the ARCS model of motivation. Both of these two theories value the importance of seeking meaning and emotional attachment. After that, two learning theories are presented: the constructivism and the transformative learning theory. Both of these two learning theories emphasize that learning is an individual and subjective process for learners to construct their own worldview, and learners must be initiated in learning. The role of storytelling when using SF is evident: it makes the teaching and learning of facts more fascinating by connecting knowledge with social context.

A story put knowledge into a concrete social setting, so learners could see how specific knowledge could be applied in a real situation. Storytelling is also an effective teaching method, which could effectively engage learners in teaching activity. When learners become engaged and focussed, it would be easier for them to imagine different perspectives of the new knowledge, for example, connect it with their previous experiences, and this is a process that learners reconstruct their knowledge system in their mine with the new knowledge they learn. Previous studies

specifically prove that storytelling is useful for adult education.

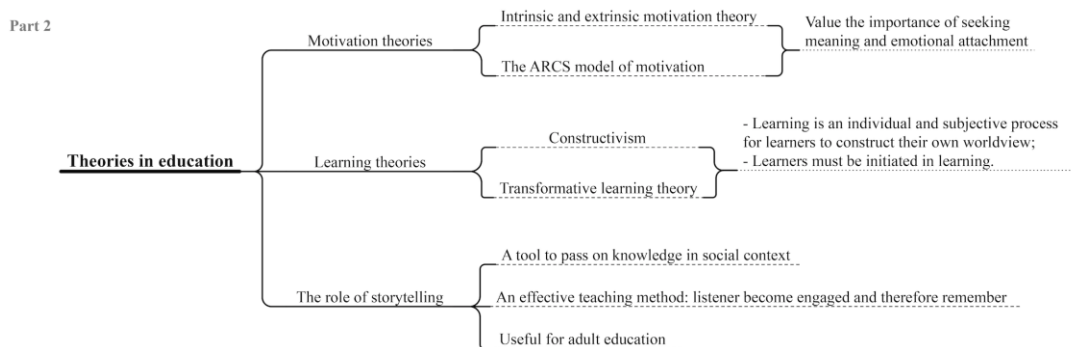


Figure 3. Theories in education.

The reviews of previous studies about using SF in education show that there are both benefits and challenges when applying SF in teaching. The benefits SF brings to education include adding interests to learning activities, enhancing learners' engagement, increasing learning motivation, making the learners remember the knowledge for a longer period, and enhancing learners' critical thinking. The challenges of introducing SF to teaching activities include first, lecturers need to integrate the SF with the curriculum, for example, carefully selecting SF movies or novels related to the content of the lectures as is done in this study. Second, SF material, for example, a movie and a novel, maybe too long to fit in a lecture, so lecturers need to reorganize the material before use it for teaching. Third, SF often contains wrong information. Lecturers should carefully identify those wrong information, and think about how to prevent students are misled by the wrong information. The application of SF in teaching includes introducing science theories, technology principles, as well as teaching the ethics of science and technology development.

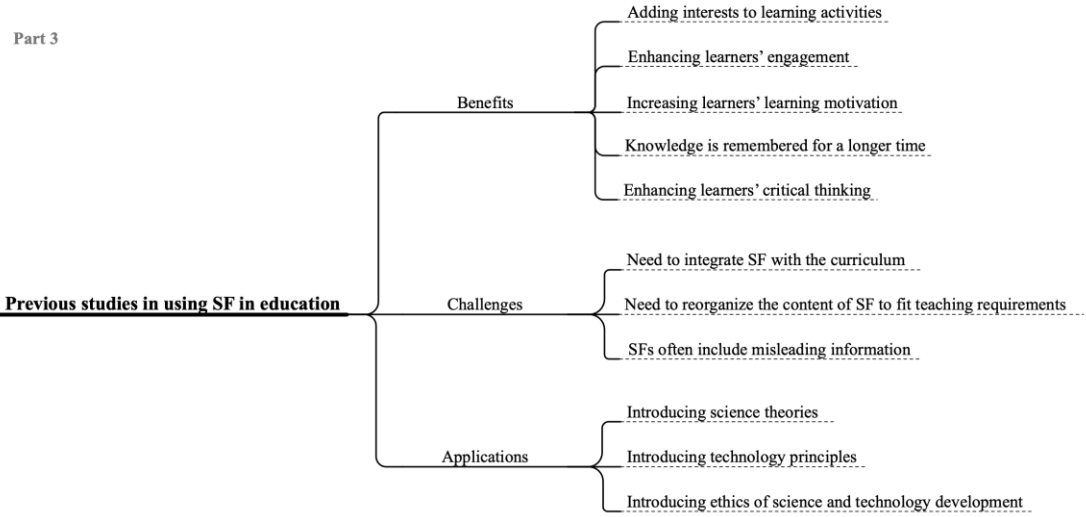


Figure 4. Previous studies on using SF in education.

3. Research questions, design and methods

3.1 Research questions and objectives

This research focuses on the topic of teaching artificial intelligence by using SF in computer science. The research is conducted in a course *Introduction to Artificial Intelligence (IAI)*. An SF story: *Hated in the Nation*, is used in the course IAI as an intervention to utilize SF in technology teaching. *Hated in the Nation* is an episode of a television series *Black Mirror Season 3*. The aim of this study is to answer the following research questions:

- What are the attitudes of students to using SF in teaching AI?
- How does watching the SF stories *Hated in the Nation* support students in learning AI at entry level?

The research objectives are:

- To find out students' attitudes to watching *Hated in the Nation* as a part of the course.
- To find out whether students would like to include some SF materials as learning materials in technical or scientific courses in general.
- To test whether the SF stories *Hated in the Nation* makes students more interested in AI.
- To test whether the SF stories *Hated in the Nation* stimulates reflection on artificial intelligence among students.
- To test whether the SF stories *Hated in the Nation* stimulates reflection on the ethics of AI among students.

3.2 Theoretical perspectives and research methodologies

In this subchapter, the theoretical perspectives and research methodologies of the research are discussed. Gray (2004a) suggests that a research process should include the following stages: epistemology, theoretical perspective, research approach,

research methodology, timeframe, and data collection methods. This subchapter follows the research process suggested by Gray to discuss most of the stages of this research, except the stage of timeframe.

3.2.1 Ontology and epistemology

In the following, first, ontology and epistemology are defined. And then discussing which type of ontology and epistemology are adopted in this research. Easterby-Smith et al. (1991) point out, as cited by Gray (2004b:p.17), “having an epistemological perspective is important for several reasons. First, it can help to clarify issues of research design. This means more than just the design of research tools. It means the overarching structure of the research including the kind of evidence that is being gathered, from where, and how it is going to be interpreted. Secondly, a knowledge of research philosophy will help the researcher to recognize which designs will work (for a given set of objectives) and which will not. ”

“Ontology is the study of being, that is, the nature of existence. While ontology embodies understanding what is, epistemology tries to understand what it means to know. Epistemology provides a philosophical background for deciding what kinds of knowledge are legitimate and adequate” (Gray, 2004a:p.16) Ontology could be divided into two traditions, ontology of *being*, and ontology of *becoming* (Gray, 2004a). The ontology of *being* believes that the reality is “seen as being composed of clearly formed entities with identifiable properties” (Gray, 2004b:p.17). In contrast, the ontology of *becoming* emphasize “formlessness, chaos, interpenetration and absence” (Gray, 2004b:p.17). Epistemology could be classified as objectivism, constructivism, and subjectivism. Objectivism holds that “reality exists independently of consciousness” (Gray, 2004b:p.17), and “research is about discovering this objective truth” (Gray, 2004b:p.17). Constructivism holds that “truth and meaning do not exist in some external world, but are created by the subject’s interactions with the world. Meaning is constructed not discovered, so subjects construct their own meaning in different ways, even in relation to the same phenomenon” (Gray, 2004b:p.17). According to Chia (2002) as cited by Cray (2004b:p.17) “Both

interpretivism and objectivism are still based upon a *being* ontology". "For subjectivism, meaning does not emerge from the interplay between the subject and the outside world, but is imposed on the object by the subject. Subjects do construct meaning, but do so from within collective unconsciousness, from dreams, from religious beliefs, etc" (Gray, 2004b:p.17).

This research adopts constructivism as the epistemological perspective, which is based upon a *being* ontology. While studying the topic of using SF in teaching, an absolute objective answer does not originally exist in the external world. On the contrary, for this topic, the opinions of people who involve in are important, including the teachers, the students, and the researchers. The empirical research of this study focuses on studying the opinions of the students.

3.2.2 Theoretical perspectives

After choosing an epistemology, the next step is to adopt a theoretical perspective that congruent with the chosen epistemology. And various research methodologies are developed from different theoretical perspectives. Gray (2004b) introduces the following five types of mainstream theoretical perspectives of research: positivism, interpretivism, critical inquiry, feminism, and postmodernism.

This study adopts the theoretical perspective of interpretivism. "Interpretivism believes that there is no direct, one-to-one relationship between ourselves (subjects) and the world (object) ... Interpretivism asserts that natural reality (and the laws of science) and social reality are different and therefore require different kinds of method. While the natural sciences are looking for consistencies in the data in order to deduce 'laws' (nomothetic), the social sciences often deal with the actions of the individual (ideographic) " (Gray, 2004b:p.20). This study explores students' actions and opinions toward learning AI with SFs. Each student has an independent feeling and opinion toward this research topic. There is no direct relationship between all of the students and the research topic. This is also the reason why this study mainly uses qualitative data, so each student's opinions and ideas can be understood clearly.

The interpretivist approaches include symbolic interactionism, phenomenology, realism, hermeneutics and naturalistic inquiry (Gray, 2004b). This research adopts the approach of phenomenology. "Phenomenology holds that any attempt to understand social reality has to be grounded in people's experiences of that social reality. Hence, phenomenology insists that we must lay aside our prevailing understanding of phenomena and revisit our immediate experience of them in order that new meanings may emerge" (Gray, 2004b:p.21). While building the theoretical framework for the case studies through literature review, the results of previous studies and the opinions from previous research toward using SFs in education are already clearly identified. To follow the phenomenology approach, when gathering qualitative data for the study, the research method is carefully designed in order to minimize the effects of the previous research to the students' opinions. The student volunteers of this study are not familiar with the previous studies of using SFs in education, and they are encouraged to express their ideas freely. Thus, this study tends to be explorative.

3.2.3 Research methodology

This empirical research is a case study. According to Gray (2004b), a case study can be inductive, deductive, or both. A purely inductive or exploratory case study starts with no theoretical position. Usually, several cases are studied independently. Some of the concepts found in the first case will be used to the data collection and analysis in the following cases. The focuses of subsequent cases shift as new findings are constantly generated in new cases. Thus, in a purely inductive or exploratory case study, comparing the result or drawing a cross-cases conclusion is difficult or even impossible. A more deductive case study method can solve this problem. For example, when several cases are studied, a theoretical framework can be first established based on the first case. After that, the cross-cases data of the remaining cases could be analysed to confirm or reject the original theory (Gray, 2004b).

The case study in this research is both inductive and deductive. Before collecting data from the case, a theoretical framework is built based on previous studies. The theoretical framework consists of three parts. And the case study focuses on the

third part of the framework, which is presented as Figure 4. The data gathered from the case is analysed to confirm or reject the third part of the theoretical framework.

3.3 Research context

In this subchapter, the general information of the selected case is presented. Since the case study is done in the course IAI, first, the teaching content and grading regulation of the course is presented below. And then a summary of the selected SF story *Hated in the Nation* follows, and how the content of *Hated in the Nation* relates to the course IAI is also discussed.

3.3.1 Course *Introduction to Artificial Intelligence*

The course IAI is an optional course for bachelor's degree students who are studying their major in Data Science at Aalto University (Finland). "This course is intended as a primer in artificial intelligence (AI). The course goes through basic concepts (with examples) in AI, covering topics in symbolic AI, data mining, and machine learning. The overall goal is demystifying these concepts and giving the students a basic understanding of the past, the present, and a bit about the future of AI. This course is intended as a non-technical introduction, which means that prior skills in programming or mathematics are not required" (Solin, 2019a:p.4). The outcomes of this course are: "After the course, the student has an understanding about basic concepts in AI, ML (machine learning). The student should understand the setup behind common AI systems, and know some of the possibilities and limitations they have" (Solin, 2019a:p.4). Students' achievements in the course are assessed by lecture quizzes, computer exercises, and a course essay. In order to pass the course, "each of these need to be completed, and the grade is compiled by (a) combination of these three" (Solin, 2019a:p.5). The students were assigned, in total, six lecture quizzes, three computer exercises, and one course essay. One lecture quiz is assigned each week, and one computer exercise was assigned every two weeks as the lectures are going on. Students should complete the lecture quizzes and the computer exercises within one week after they are assigned. The course essay should be

written after all the lectures and should be submitted within two weeks after the last lecture. In the course essay, students should reflect on the course content and tie it to their own experiences and thoughts about AI. For example, students could relate the concepts and things the course have explored to their own field of study or their fields of interest, or contemplate where we are going in AI and how things will change in the future. Students had much freedom in choosing what to focus on in the course essay (Solin & Hou, 2019).

The grading rules of the course are presented at the following:

“6 lectures × 10 points/quiz = 60 points

3 exercises × 10 points each = 30 points

Essay: 4 points × 7.5 scaling factor = 30 points

Extra: Feedback (2 p) and the voluntary exercise (4 p)

Maximum of 120 points (+ 6 p)” (Solin & Hou, 2019:p.9)

The grade limits are as follows:

“Grade 5: 112 points

Grade 4: 99 points

Grade 3: 88 points

Grade 2: 80 points

Grade 1: 60 points” (Solin, 2019b:p.1)

3.3.2 SF as a part of the course

The selected SF story for this case study is *Hated in the Nation*. It is the 6th episode of a television series *Black Mirror Season III*. *Hated in the Nation* tells a story about what happens in the near future where the normal wild honey bees are almost extinct because of climate change. The UK government releases the Autonomous Drone Insect (ADI) around the country. The public is told that the ADIs are only released to do the job of the wild honey bees. However, the ADIs are actually multifunctional, and the government also secretly use them for other purposes, for example, collecting information around the country, since the ADIs are able to access

everywhere. And the ADIs are armed. The worse thing is, a hacker hacks inside the controlling system of the ADIs, so the ADIs become a scary weapon to kill whoever is targeted (Brooker, 2016).

The student volunteers were required to watch the selected SF *Hated in the Nation* before the last lecture of the course on the 5th of April, 2019. Then they should finish their course essay before the 18th of April as all other students. Student volunteers were informed that if they found the *Hated in the Nation* inspiring when writing their course essay, they were welcome to mention it in their course essay. For example, if a student wants to talk about the face recognition technology, which could be dangerous if somebody uses it in an improper way. Then he/she could give an example to explain, what kind of improper way, and what kind of result it might bring, and maybe further, how to prevent it. He/she may find several scenes in the video similar to his/her idea, so he/she could use them as examples in his/her course essay. Student volunteers were totally free to choose whether to discuss the SF story in their course essays. If they would like to discuss it, they were also free to discuss the SF story in any way they like.

The reason why *Hated in the Nation* is selected for the case study is that the story covers many topics in the course, and the story also discusses the ethics of AI from a special angle. The content of *Hated in the Nation* will be analysed deeper later in this section. Moreover, *Hated in the Nation* is a very good television work and is interesting to watch. *Hated in the Nation* is a 90 minutes episode, which contains much information that cannot be all analysed in this study. Thus, in the following of this section, the technologies, which appear in the episode and are related to the first lecture and the last lecture, are discussed as examples to explain how the AI concept in *Hated in the Nation* could be related to the teaching content. Some interesting findings outside of the course IAI are also presented.

Inside the course *Introduction to Artificial Intelligence*

The first lecture of the course IAI introduces what AI is. The lecture starts from the big picture of AI and the historical perspective of AI. Classical concepts in the AI

development process are introduced, including the Turing test, the Chinese room argument, strong AI and weak AI, as well as general AI and narrow AI. The lecture then gave the definition of AI cited from the EU (2018): “Artificial intelligence (AI) refers to systems that display intelligent behaviour by analysing their environment and taking actions—with some degree of autonomy—to achieve specific goals. AI-based systems can be purely software-based, acting in the virtual world (voice assistants, image analysis software, search engines, speech and face recognition systems) or AI can be embedded in hardware devices (advanced robots, autonomous cars, drones or Internet of Things applications)” (Solin, 2019c:p.27). Several examples from the real world were discussed as a practice for students to use new knowledge. A list of items was shown, and students were asked to distinguish whether these items were AI, and what types of AI they were. The examples included the app of Google Map, the facial recognition setting in iPhones, a GPS navigation device, and a robot produced by Boston Dynamics. SFs with a theme of AI were also mentioned to discuss the perceived image of AI for the general public. The ADIs in *Hated in the Nation* could be a good example for discussing what AI is and how to define different types of AI in the first lecture. When looking at the definition of AI by the EU, the description is abstract. However, the SF story *Hated in the Nation* and the ADIs could provide a precise and concrete background for discussing such an abstract definition. The ADIs can analyse the environment through the GPS system and graphics recognition system, and can autonomically complete the task of pollination. The ADIs are embedded in hardware devices, which looks like the wild honey bees. According to the definition of AI from the EU, the ADIs are AI. Further, since the ADIs are only act intelligently instead of really being intelligent, and they can only handle specific tasks instead of any task, the auto bees should be classified as both weak AI and narrow AI.

The 6th lecture was the final lecture of the course IAI. The topic of this final lecture was “*Impact and Ethics of AI*”. In general, the lecture included the following subtopics: societal impact, fairness and biases, transparency and accountability, as well as ethics (Solin, 2019d). Students were very interested in those topics and were very active during the discussion. One of the interesting questions arose in the

lecture was: Who is responsible for the actions of an AI? Students were eager to give their answers, and they thought of very different perspectives. On the one hand, it was good that the discussion brings out a wide range of opinions. On the other hand, it was also difficult to go deep in the discussion, since lacking a concrete background, and students need to make many assumptions before they try to give their opinions. *Hated in the Nation*, again, would provide very good discussion materials for the students. In the story, the writer has created a series of specific roles who more or less involved in the ADIs releasing project and later the crime, including the government, the scientists, the public, etc. Assuming that the students had watched *Hated in the Nation* before the last lecture, and the discussion was based on the description in *Hated in the Nation*, then the discussion would easily go deeper as all the settings were specific. Even though *Hated in the Nation* was actually not discussed in the lecture, the lecture did mention AI concept from SFs. The Three Law of Robotics was discussed in the lecture, which was proposed by a famous SF writer Isaac Asimov. The Three Law of Robotics include: first, a robot may not injure a human being or, through inaction, allow a human being to come to harm; second, a robot must obey orders given it by human beings except where such orders would conflict with the First Law; third, a robot must protect its own existence as long as such protection does not conflict with the First or Second Law (Asimov, 1950). The Three Law of Robotics has a great influence on SF works. For example, the movie *I, Robot*, which is directed by Alex Proyas, discusses the validity of The Three Law of Robotics. Obviously, the ADIs do not obey The Three Law of Robotics since they can attack human beings. Should scientists and engineers obey The Three Law of Robotics while designing new AI invention in order to prevent any tragedy like what happens in *Hated in the Nation*? Or is The Three Law of Robotics actually practicable? On the lecture, Solin (2019a) also gave examples to discuss the validity of the first law: a robot may not injure a human being or, through inaction, allow a human being to come to harm. One of the examples was: for an auto-drive car, if the AI on the car detects an inevitable traffic accident is about to happen, then how should the AI on the car decide whether to protect the passengers inside the car or the passengers walking on the road? How can the AI make “a proper decision” without violating the first law of The Three Law of Robotics? This was a good example of how an AI

concept appearing in SF could actually bring up interesting discussion topics when combining with the teaching content, despite whether the concept in SF is correct or debatable.

Outside the course *Introduction to Artificial Intelligence*

Going beyond the lecture, more scientific evidence could be found to support or to be related to the settings of the story. The story happens based on a background of the ADIs releasing. And this background is relevant to what is happening in reality. First, wild honey bees are decreasing. “Throughout history, wild honey bees have experienced population decreases – including the 1860s, the 1970s, the 1980s – however, their populations have drastically decreased since the 1980s and continue today” (Reed, 2018:p.16). Second, the study of auto bees is in progress. “Automated pollinators in the form of robotic bees are a potential solution that scientists are working on to act as the wild honey bee does. There are several laboratories that have created alternate methods of pollination, specifically the Harvard School of Engineering and Applied Sciences and the National Institute of Advanced Industrial Science and Technology in Japan” (Reed, 2018:p.17). “At this point, the robotic bee drones can successfully pollinate flowers in a laboratory setting. However, they are currently not autonomous. Instead, they require a human controller to complete pollination. However, strides are being made to make these drones autonomous by incorporating artificial intelligence, GPS, and a camera” (Reed, 2018:p.17).

3.4 Data collection

In this subchapter, the whole data collection process is presented. In general, the present study first builds a theoretical framework based on previous studies, which has been presented in chapter 2. The literature review of this study mainly includes three types of literature, background information of SF, theories in education, and the previous studies in using science fiction in education. The purposes of the literature review are, first, to find out what are already known in the field of using SF in education; second, to find a proper research perspective for this study; and third,

to summarize a theoretical framework for the empirical research. After that, the empirical research--a case study--is conducted, and both qualitative and quantitative data are collected and analysed. The results of the empirical research are compared with the theoretical framework that built based on previous research. The goal of this study is to obtain information related to the research questions of this thesis. The research questions are answered by analyzing both the answers to the questionnaire and the answers to the open question.

Students who were taking the course voluntarily joined to the empirical research. To recruit student volunteers, this study was presented in an exercise session of the course which had about 50 attendants. The slides of the presentation were available on MyCourses, and all the students who were in the course were also able to access the slides. The students who completed the research were rewarded with 4 extra points to their final scores and had an opportunity to participate in a raffle for free movie tickets. 10 movie tickets were given to five students, each lucky student got two tickets. In total, about 170 students completed the course, and 44 students voluntarily participated in the empirical research.

3.4.1 Questionnaire

The volunteers filled in an online questionnaire. The questionnaire can be found in Appendix A. The purpose of the online questionnaire was to find out students' attitude to watching *Hated in the Nation* as part of the learning process of the course IAI, and how they think watching *Hated in the Nation* support them in learning the content of the course. The volunteers were also required to upload their course essay and their answers to the open question as an attachment to the online questionnaire. Since the questionnaire concerns personal information, for example, the students' email address, the students were also sent a Privacy Notice to make sure that they fully understand how the information collected for this research will be used, and how they can terminate the use of their information. The Privacy Notice can be found in Appendix B. The data collection and management method of this study is aligned with GDPR.

In short, the questionnaire consists of 4 sections. Before collecting information related to the study, in the first section of the questionnaire, students are asked to give their permission to ask them questions related to this study, and to give their permission to use their answers in this study. The second section asks students' personal information, such as contact information and personal background. The third part consists of 12 questions related to students' attitudes to the teaching method of using SFs as learning materials. Students were asked to answer the questions with a scale from 1 to 6, and these numbers respectively represent "extremely agree", "moderately agree", "slightly agree", "slightly disagree", "moderately disagree" and "extremely disagree". The fourth part is the open-form questions, and the volunteers are asked to upload their course essay and their answers to the open questions.

3.4.2 The open question

The open questions were designed to gather information to answer the second research question. However, when answering the open question, the students also give comments on using *Hated in the Nation* for teaching AI. These comments are related to the first research question. Thus, students' answers to the open question were analysed to answer both the first and the second research question.

The voluntary students were asked to answer the open question, and submit it together with their course essay. The open question was: "What did you learn about AI from the video? Describe how does it relate to the topics of the course?" The answer to this question should be about half-page long (around 150 to 200 words).

3.4 Data analysis

Both quantitative and qualitative data analyses are used to answer the research questions. The results of the quantitative and qualitative data analyses are not mutually independent, but supporting each other. The results of the quantitative

data analysis show students' attitudes or reflect their thoughts in general, while the results of the qualitative data analysis present concrete answers from the students. For example, with the quantitative data, we could find the answer of whether students think watching the SF as part of the learning process is interesting, while from the qualitative data, we could find exactly which part of the SF that students are interested in.

"There are, essentially, two ways in which the case study evidence can be analysed. The first is to analyse the data on the basis of the original theoretical propositions and the research objectives that flowed from them. The other is to develop a descriptive framework once the case study has been completed" (Gray, 2004b:p.139). The data analysis process of this research combines both of these two methods. First, both the quantitative and qualitative data are analysed to find out benefits, challenges and applications of using SF in teaching AI in this specific case (inductive). And then, the empirical results of the case study are compared with the third part of the framework that is built based on the literature review (deductive). The purpose of the comparison are: 1) to find out whether the results of the case study support the findings from previous studies, 2) to discover possible new findings, 3) to revise the theoretical framework. On the questionnaire, students answered 12 questions with a scale from 1 to 6. A heat plot is generated to show the average attitude of the students, and how they think learning with SF could support their studies.

The qualitative data is analysed with the thematic analysis and the thematic network method with Atlas.ti. Thematic analysis is a common method for analysing qualitative data, and the thematic network method is a way to organize a thematic analysis (Attride-Stirling, 2001). A thematic network consists of three kinds of themes: Basic Themes, Organizing Themes, and Global Themes. The Basic Themes are extracted directly from the original qualitative data, for example, an original expression of an interviewee. The Organizing Themes are defined by categorising the Basic Themes and are used to summarize each group of the Basic Themes. Similarly, the Global Themes are used to summarize each group of Global Themes. A thematic network could have one or more Global Themes. Figure 5 shows the relationship

between these three kinds of themes by showing the structure of a thematic network (Attride-Stirling, 2001:p.388).

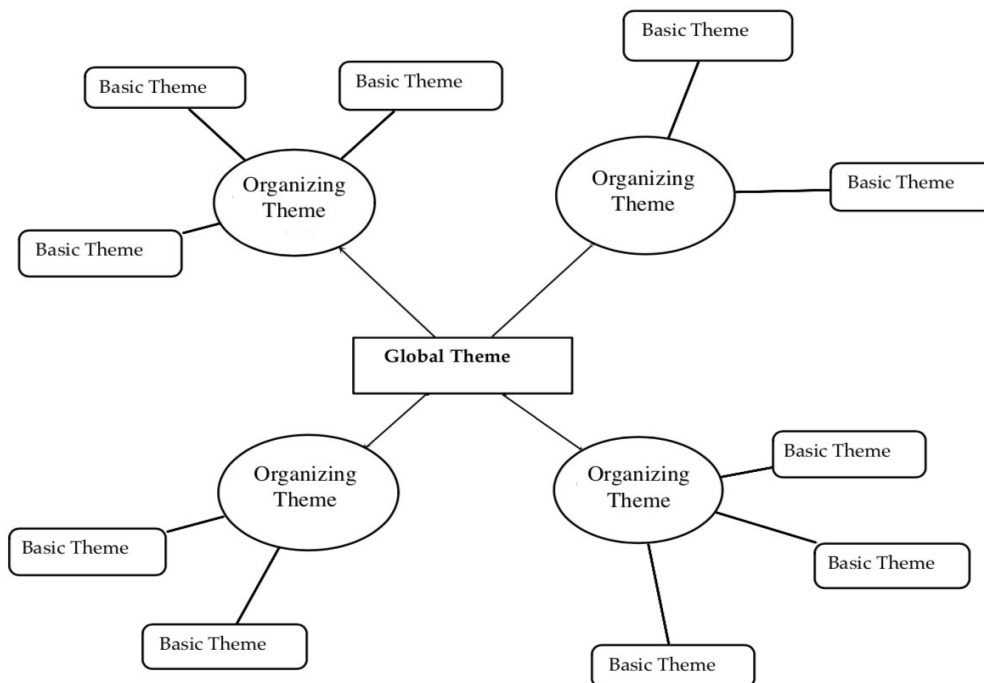


Figure 5. Structure of a thematic network (Attride-Stirling, 2001:p.388).

In this study, the original thematic analysis method is expanded into five types of themes: Basic Themes, Sub-organizing Themes, Organizing Themes, Sub-global Themes, and Global Themes. A sub-organizing theme is applied, when the basic themes in the same organizing theme are fertile, and at least some of the basic themes could be further grouped into one or more sub-organizing themes. Similarly, a sub-global theme is applied, when the organizing themes in the same global-theme are fertile, and at least some of the organizing themes could be further grouped into one or more sub-global themes. Figure 6 shows the relationship between these five kinds of themes.

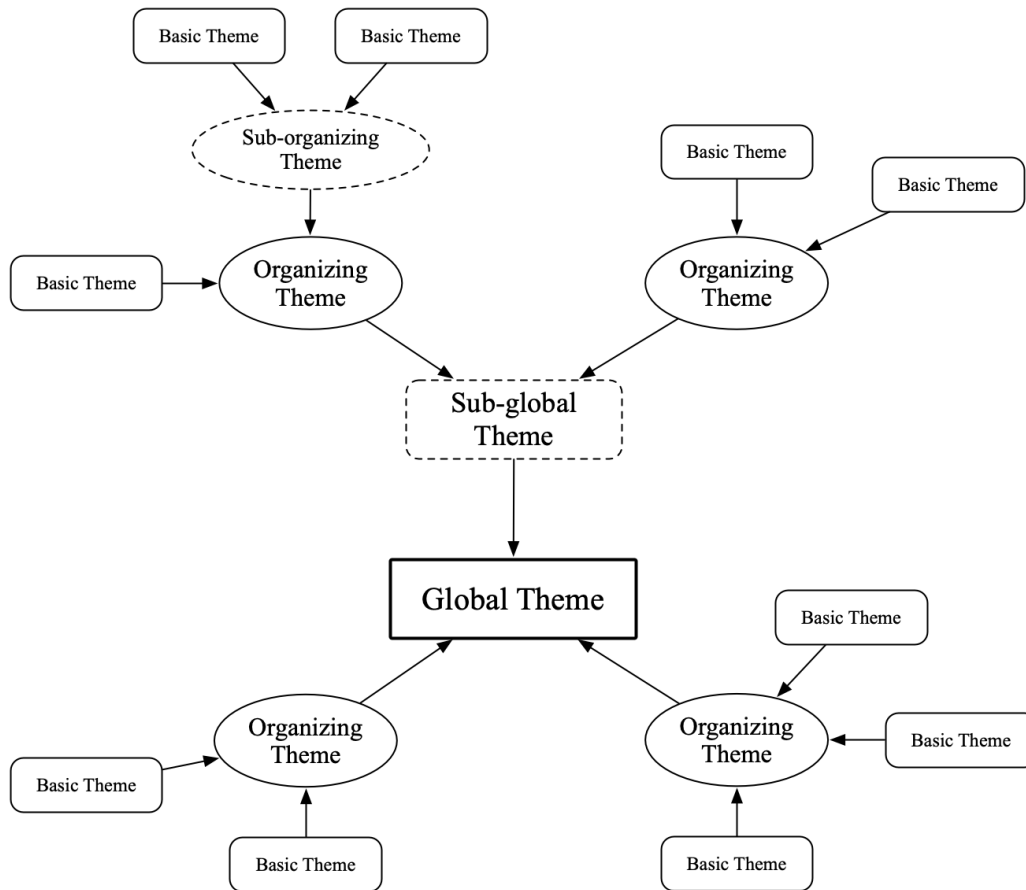


Figure 6. Revised structure of a thematic network.

At the following, the thematic analysis method applied to analyse the answers to the open question is explained. Below, a part of the answer from the student no. 24 is presented.

The video "Hated in the Nation" demonstrated the consequences of using AI solutions without proper caution and let the audience ponder over the liability for who should be held accountable in case of a breach to such critical systems. It showed how easily a benign system can be turned into a weapon of mass killing. The ADI drones were programmed for a specific benevolent task (example of narrow and weak AI) but were turned into a device of public surveillance by the government using the backdoors in the system. The control system although encrypted with military-level encryption algorithm

failed due to breach in underlying software control and was turned into a killing machine. It further brings home the necessity of a liability model, which party should be held responsible for the breach; the ADI development company which released such critical AI without proper testing and review channels in place or the government who unlawfully used those drones, performed privacy-breach and excavated the attack by providing both-way access to the confidential database resulting in increased attack surface for the adversary. The video directed attention to the liability of mishaps occurring due to AI systems as well as the absolute need for caution while dealing with safety-critical AI systems. Risk-analysis, emergency shutdown procedures, AI behaviour analysis are some aspects that need to be focused upon in developing systems that are safe and privacy-critical and closely knit in the personal lives of people...

In the analysing process, the underlined sentence from the student's answer is first selected as a basic theme. The selected sentence is then coded with a code of "responsibility of AI controlling". The code of "responsibility of AI controlling" is an organizing theme. All of the contents that discuss who should hold the responsibility of AI controlling are coded with the organizing theme of "responsibility of AI controlling". The organizing theme of "responsibility" then further group into a sub-global theme: "Ethics of AI". The sub-global theme of "Ethics of AI" belongs to the global theme of "Reflections on learning contents". The sub-organizing theme is not applied in this case. An example of sub-organizing theme is, for the organizing theme of "New Type of Crime", two sub-organizing themes are identified: the sub-organizing theme of "AI misuse", and the sub-organizing theme of "surveillance". The examples mentioned above are visualized in Figure 8 in section 4.1.2.

After analysing the answers to the open question, three global themes are identified. They are "comments on using *Hated in the Nation* for teaching AI", "opinions to the content of *Hated in the Nation*", and "reflections on learning contents". These three global themes will be introduced in detail in the next chapter. For each global theme,

a thematic network is generated to present its content.

4. Findings

In this chapter, the findings of this study are presented according to the research questions and the research objectives. The subchapter 4.1 is divided into two sections based on the research questions. In the end, a new framework is created to present the results of the case study in subchapter 4.2.

4.1 Learning with *Hated in the Nation*

The aim of this subchapter is to answer the research questions. In the following, all findings from the students' perspective are presented. First, the students' attitudes and thoughts toward using SF as teaching materials are shown. Second, the learning outcomes of studying with SF are reported. In general, section 4.1.1 shows how students think about using SF in teaching, while section 4.1.2 finds out what the students really learn by looking at how they answer the open question.

4.1.1 Students' attitudes and thoughts to learning with science fiction

Students' attitudes toward using SFs as teaching materials, and how students think SF may support their study are presented in this section. We first look at the 12 questions in the third section of the questionnaire, which are directly related to the students' attitudes and thoughts. And then, we will look at students' answers to the open question. Many students give comments on the new teaching method when answering the open question.

In general, the survey study (Figure 7) shows that:

2.1 Students **STRONGLY AGREE** that they enjoy watching the video "*Hated in the Nation*" for the course of Introduction to Artificial Intelligence.

2.2 Students agree that the video reminds them of the knowledge they learn in the course.

2.3 Students agree that watching the video makes the content of the course more interesting to them.

2.4 Students agree that they are able to think about the technology of AI while watching the video, applying course materials to the concepts presented in the video.

2.5 Students **SLIGHTLY AGREE** that watching the video helps them understand the technology of AI.

2.6 Students **STRONGLY AGREE** that watching the video helps them understand the ethics of AI.

2.7 Students **STRONGLY AGREE** that watching the video helps them think critically about the ethics of AI.

2.8 Students agree that using the video to present/learn AI technology is helpful.

2.9 Students agree that the video makes them more interested in the technology of AI.

2.10 Students agree that the video inspires their imagination about AI.

2.11 Students agree that they would like to see some science fictions as learning materials in other courses that introduce technology concepts.

2.12 Students agree that the video gives them some inspiration for writing my course essay.

A heat plot for students' answers to each of the questions is shown in Figure 7. In Figure 7, for each question, the average score, the medians and the standard deviation of the students' answers are shown.

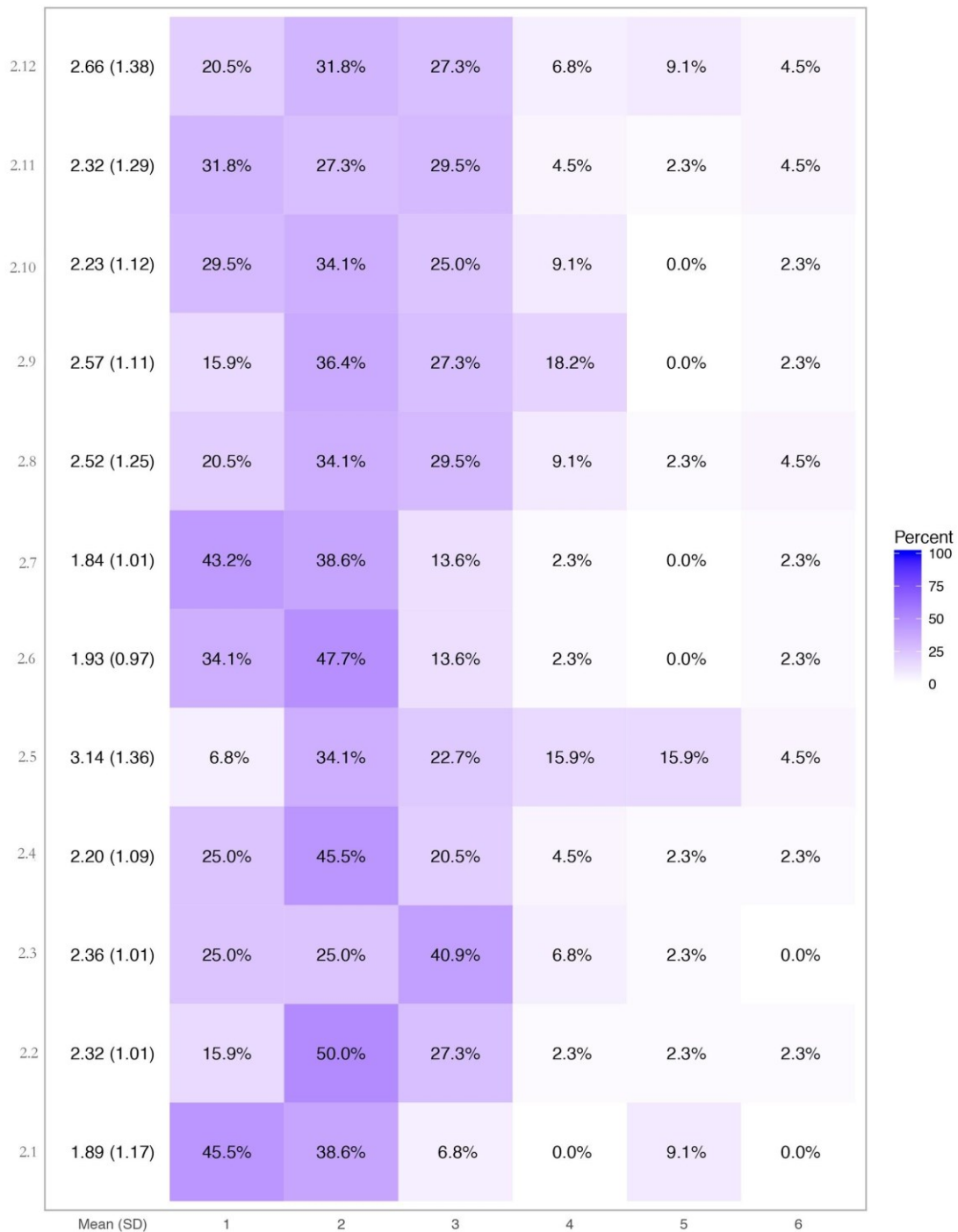


Figure 7. Students' averaged attitudes to learning with science fiction (1 = "extremely agree", 2 = moderately agree, 3 = slightly agree, 4 = slightly disagree, 5 = moderately disagree, 6 = "extremely disagree").

As shown by Figure 7, for each of the 12 questions, all of the average scores are below 3.50. By calculation, the average score of all the questions is 2.33. This means that on average, students have a positive attitude towards using SF as teaching

material in all of these 12 aspects. The colour of the heat plot further proves this finding. The colour of the heat plot reflects the percentages of the answers to each question. For each of the questions, most of the students give their answers from 1 (“extremely agree”) to 3 (“slightly agree”).

The answers to questions 2.1, 2.6 and 2.7 are especially positive. The average scores for these three questions are 1.89, 1.93, 1.84. And for these three questions, the distribution of the answers focus on 1 to 2. This means students strongly agree that they enjoy watching the SF video and the SFs help them both understand and think critically about the ethics of AI. Students only slightly agree on question 2.5. The average score of the question 2.5 is 3.14, which is the highest one among these 12 questions. On average, students slightly agree that watching *Hated in the Nation* helps them understand the technology of AI. In other words, students find that watching *Hated in the Nation* only have limited help in understanding AI technology.

While answering the open question after finishing the course, some of the students give comments on using SFs as teaching materials. Both positive comments and negative comments were received. In total, 26 out of 44 students directly give their comments to this new type of teaching material. 34 comments from students are marked, include 25 positive comments and 9 negative comments. Some students give both positive comments and negative comments parallelly. This is reasonable as most of affairs have two sides. Students’ comments are summaries in Figure 8.

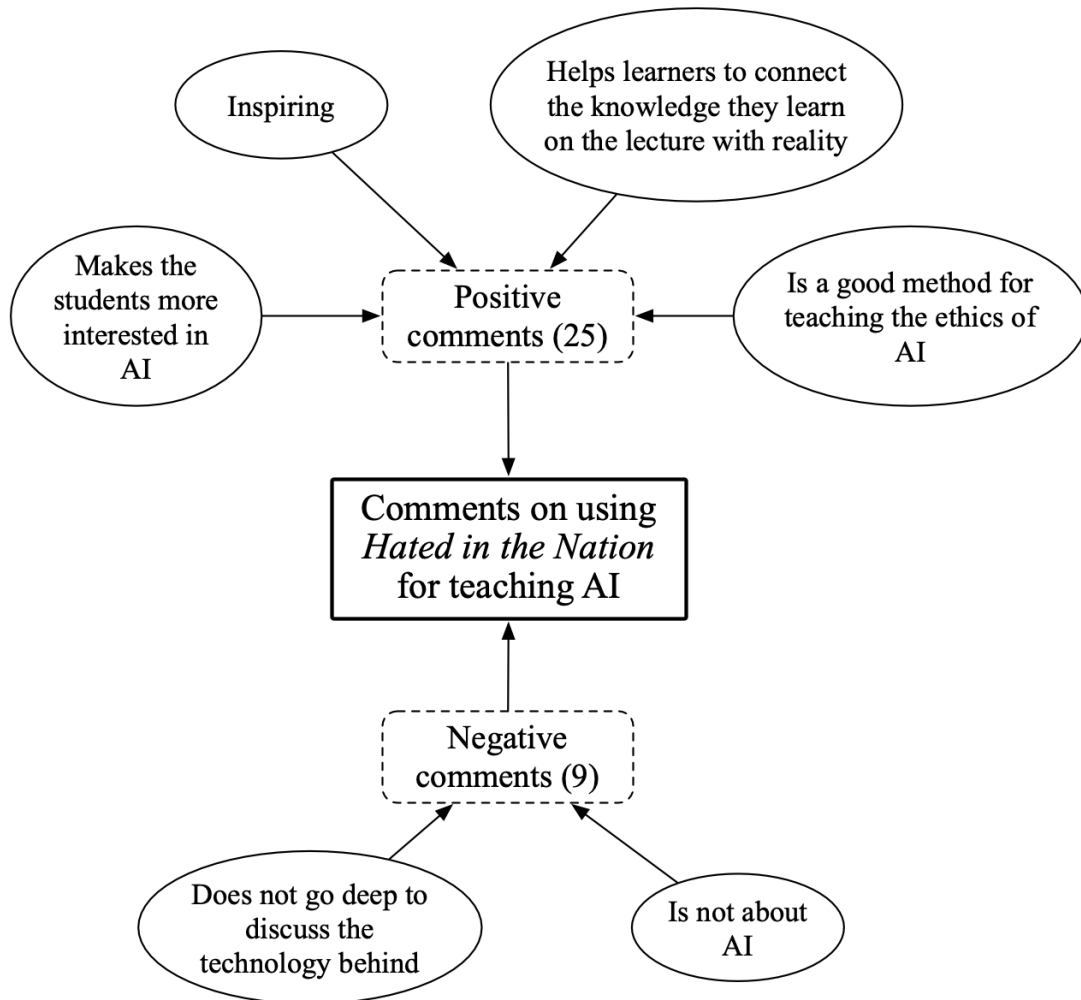


Figure 8. Students' comments on using *Hated in the Nation* for teaching AI.

Positive comments

Students give positive comments mainly on finding the SF story: 1) make them more interested in AI, 2) inspiring, 3) helps learners to connect the knowledge they learn on the lecture with reality and 4) is a good method for teaching the ethics of AI. For example, Student No. 8 expresses that watching the SF story as part of the learning process is interesting:

It was interesting to watch the film when I knew what was behind the AI bees that the hacker programmed to kill the people... This chapter of the Black Mirror made me want to see more chapters since I got curious and more interested about the AI - mainly because

of the course since now I have a little clue what is behind these “science fiction theories”.

Student No. 38 mentions that after taking the course, he/she is able to pay more attention to the AI technology appearing on the SF story:

When I was watching the video, I noticed that I now pay remarkably more attention to AI than before the course. I was constantly thinking which technologies were AI and which were not.

Student No. 8 also expresses that watching the SF story may inspire him/her for writing his/her course essay:

To be honest, I watched the Black Mirror chapter after writing the course essay. It might have been easier to write the essay after watching the video since the film included a lot of AI and it would have been of help...

Similarly, Student No. 26 finds the story is inspiring for reflection and discussion:

In my opinion, the episode of Black Mirror was useful to generally reflect on implications of technology and stimulated the discussion with other students...

Being able to connect the knowledge learned from the lecture to reality is very important to a learner. The following comments from students are found as examples of how the SF story helps them to connect the knowledge and reality.

Hated in the Nation was an interesting episode that gave me a lot of knowledge that helps me a lot to understand how artificial intelligence is working and to understand the strong relationship that it has with society, ethics and privacy. (Student No. 17)

Hated in the nation was a meaningful science fiction film, as it wasn't too futuristic but wanted to shake up people to think that this really might happen. (Student No. 7)

The video showed me an example of how certain points we discussed in the lecture could turn out in reality. (Student No. 31)

Many students mention that teaching with SF is a very good way of teaching ethics. Examples are also found. Student No. 33 proposes that SF make a great impact on teaching ethic compare to other materials:

I think that Sci-Fi can provide a great means of teaching about AI... On the other hand, subjects such as ethics of AI or responsibility with AI can be hard to teach by lectures, and more importantly might not make such a great impact, as Sci-Fi might do.

Student No. 40 advises that students whose major in subjects related to the ethics of technology development would benefit the most from learning with SF materials:

Ethics and openness of the automated systems should be discussed more in the society and Science Fiction stories are excellent in this regard to open our eyes... Science fiction could be used for educational purposes more relevantly in non-technical subjects. Studies related to law, politics, ethics and society would benefit from this kind of exploration.

Negative comments

Compared to the positive comments, only a few negative comments appear in students' course essays. They are mainly commenting that the story *Hated in the Nation* does not go deep to discuss the technology behind. Several students even comment that the selected SF is not about AI. For example, student No. 3 gives such

a comment:

To be honest, I don't think that I got a deeper insight into the risks and potentials of AIs since in my opinion the Black Mirror episode "Hated by the Nation" only looks at the AI system on a very basic level.

Student No. 8, whose positive comment has been mentioned previously, also write a negative comment:

I personally hoped that the film would have dug more deeply into AI but I understand that at the same time the director has wanted to make the film easy to follow for everyone.

Student No. 34, recommends three other SF materials: *Westworld*, *Ex Machina* and *2001: A space odyssey* while he/she also expresses that *Hated in the Nation* contains limited technology information:

The episode did not teach me anything new about AI and I am surprised to see this as the episode from Black Mirror chosen for this study. However, I am delighted that it got me to give Black Mirror another chance as a dystopian commentary TV show. I have not seen many episodes of the show but I believe there must have been episodes that bring forth the ethical implications of AI in much better ways than this. Commentary of ethical implications of AI is running rampant in pop culture now following the recent AI hype. Why not choose an episode of Westworld or a movie like Ex Machina or even a classic like 2001: A space odyssey?

Student No. 33 points out another disadvantage of the teaching method is the video is too long to be watched for learning purposes.

I think that the problem with, for example, the episode is that the teaching has a low learning to time used ratio. One had to watch a one and a half an hour video to learn what could be learned.

4.1.2 Learning outcomes

In this section, we focus on discovering what students really learn from SF by analysing their answers to the open question. Thematic analysis is applied to analysing students' answers to the open question. Students' answers to the open question mainly consist of three types of content: comments on using *Hated in the Nation* for teaching AI, opinions to the content of *Hated in the Nation*, reflections on learning contents. Students' comments to the new teaching method have been analysed in the previous section, so in this section, we will continue with analysing of opinions to the content of *Hated in the Nation*, reflections on learning contents.

Opinions to the content of the SF story

SF is the "literature of imagination". SF is originally produced for entertainment rather than reflecting reality. However, what makes SF interesting and attractive is how the author combines the plausible hypothesis and reality in order to create the most unexpected story. How students think about the content of the SF *Hated in the Nation* in this case? Do students accept the hypothesis appeared in the story? Do they think the technical arguments are convincing or non-sense? How do they evaluate the technical setting after they gain some knowledge about AI from the course IAI? The students' opinions toward the content of the SF will be discussed in the following. Students' opinions are summaries in Figure 9.

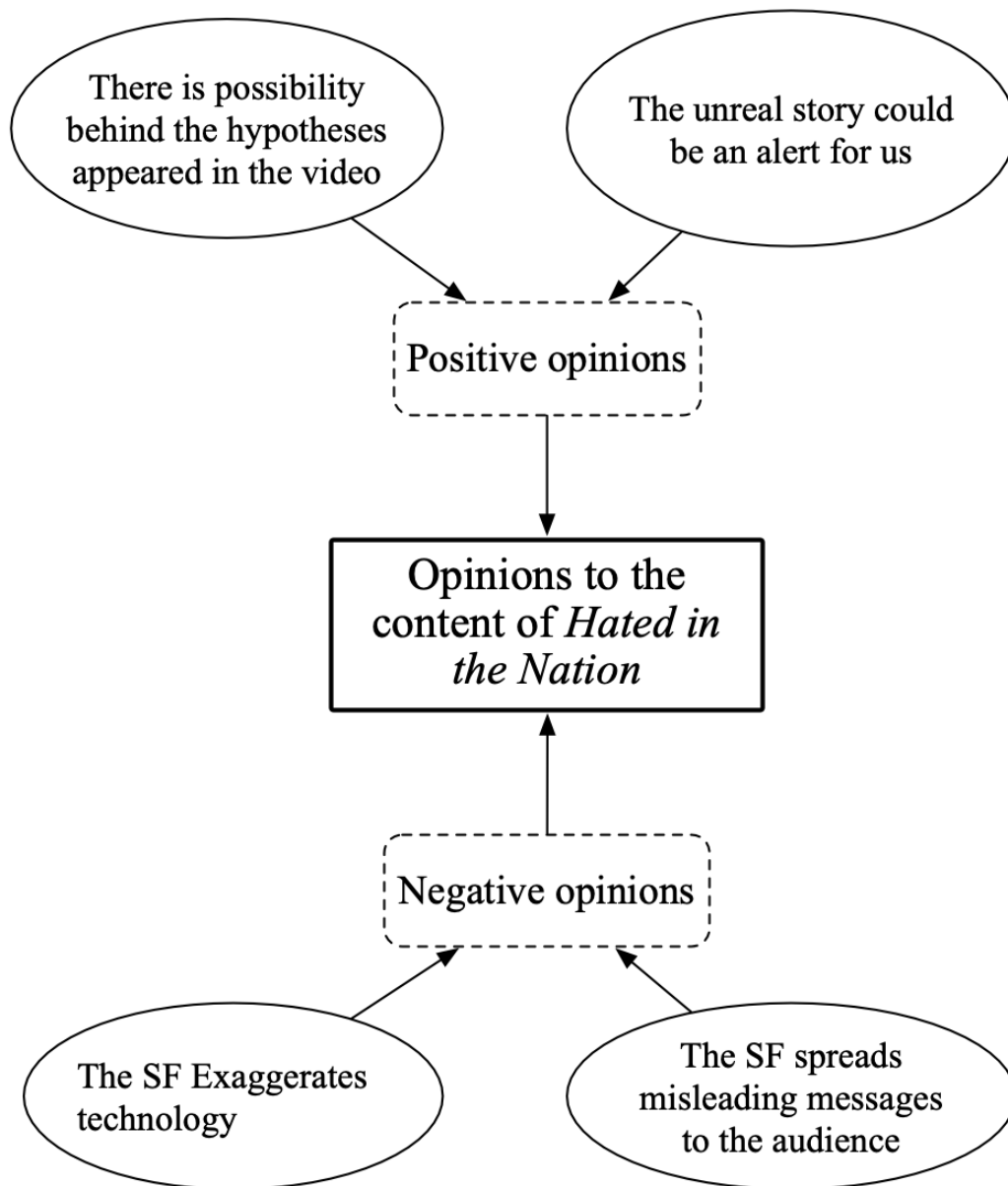


Figure 9. Students' Opinions to the content of *Hated in the Nation*.

To the fictional story, again, students present different opinions. Most of the students have positive opinions that they see the possibility behind the hypotheses appeared in the video, or see the unreal story as an alert for us, while there are also students expressing that they see that the story mainly exaggerates technology and spreads misleading messages to the audience.

Many students see the possibility that what happens in the story might happen in reality in the near future. The following contents are cited from students' answers

directly:

The video showed both the possibilities and threats connected with emerging technologies like AI. (Student No. 6)

The video depicted the possible problems of AI in case of a security breach and what AI might cause in the wrong hands. (Student No. 1)

You can clearly see the multiple sides and capabilities of AI as a wholesome system that are either already available or part of future plans/ambitions. (Student No. 21)

The bees also were able to move in big swarms and keep a specific formation. This is something that I think is possible to do with drones today. (Student No. 22)

One example is cited to show how students express that the SF story could be seen as an alert:

Although my first immediate reaction to the movie was shock and fear, after a while I thought that the plot was not entirely a new one. One could not be surprised by what happened in the movie, because there have been many other occasions to date - in reality - that with a novel and newly found technology there have been some risks and that not all scenarios and impacts have been foreseen for that technology. For example, I was a child when the electronic fruit juicer came to market and sometimes we would read the sad news that a child put his/her hand in the juicer and lost their fingers. There have also been few incidents so far where self-driving cars have hurt people. (Student No. 5)

Student No. 16 present his/her opinion about how general SFs spread exaggerated

and misleading messages about technology:

This idea could be used either to instil fear in people or intrigue them as to how far artificial intelligence could go. In this course, we discussed how new AI is difficult to think of because of how advanced sci-fi movies always presented AI to be. The downfall of this, however, is that people who aren't educated on artificial intelligence may believe that it is being created to destroy humans, when in fact, it is being created to make our lives easier. This TV show could be used as a warning, but should not be taken seriously, as people are not creating AI to end the human race.

Reflections on learning contents

Students deliver very rich reflections on their answers to the open question. The most popular topics are collected and reorganized and shown in Figure 10. The reflection from students includes seven organizing themes: responsibility of AI controlling, new types of crime, AI security, AI in reality, AI in the future, questions about the content of *Hated in the Nation*, and AI in other materials. Three organizing themes: responsibility of AI controlling, new types of crime and AI security, are further grouped into a sub-global theme: ethics of AI.

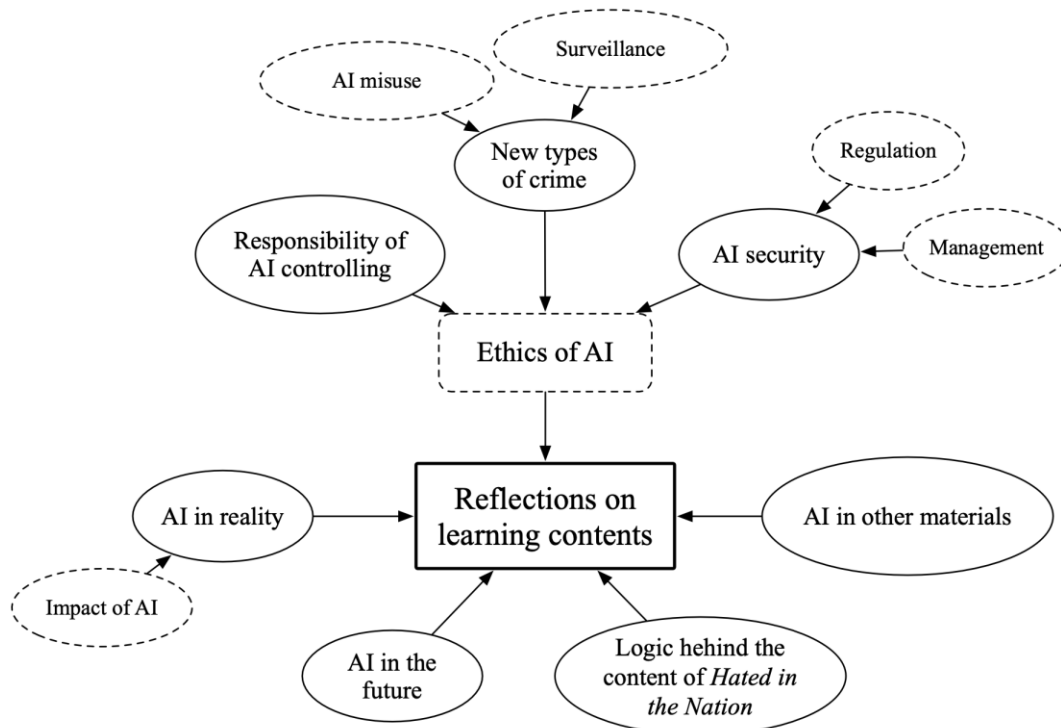


Figure 10. Students’ reflections on learning contents.

Ethics of AI

The ethics of AI is the most popular theme that appears as students’ reflections. 41 out of 44 students identify and discuss issues related to the ethics of AI. The sub-global theme of ethics of AI consists of three organizing themes: new types of crime, responsibility of AI controlling, and AI security. Many students mention that new types of crime appear with new technology. In the case of *Hated in the Nation*, the new types of crime are AI misuse and surveillance. The ADIs are originally developed for a good purpose - to maintain the balance of nature. However, in the end, the ADIs are misused by a hacker and cause a collective slaughter. Besides, the UK government secretly used the ADIs for surveillance also catches many students’ attention. Student No. 25 present his/her opinion about AI misuse as below:

In the video, Artificial Intelligence was misused and caused a tragedy. While we cannot blame anything on Artificial Intelligence as technology, but the costs of misuse of technologies is huge. With inappropriate management, Artificial Intelligence can be used as

weapons...

And the answer from Student No. 37 is another good example of AI misuse:

Technology has evolved, and it has become much easier than before to produce the same effect using the insect. The scalability of Artificial Intelligence is unbelievably incredible, however, as illustrated in the video, with great power comes with great responsibility, imagine that large scalability was misused, the effect of it is fatally enormous.

Discussing who should take responsibility when AI invention goes wrong and cause danger is also a hot reflection topic. For example:

Watching Hated in the Nation-episode made me seriously think about the security of AI and the responsibilities. Deploying AI systems raises a vital question, who is responsible. In the episode, AI-system starts to kill people according to Twitter-votes. This made me think that who is responsible for this slaughter. People are doing conscious decisions but perhaps aren't aware of what really is happening. On the other hand, even though the deployer of the system didn't design the beehive system to work like that the responsibility according to security can't be neglected (student No. 7).

In the video, there were many different parties that could be considered responsible. Is it the developer of the system, the government that regulates it, the police that could not prevent the situation from worsening or the criminal who hijacked the bees? I think everyone would think that the criminal should be punished, but others are more opinionated. Some might see the situation differently than others, and there is no clear right or wrong (Student No. 13).

It further brings home the necessity of a liability model, which party should be held responsible for the breach; the ADI development company which released such critical AI without proper testing and review channels in place or the government who unlawfully used those drones, performed privacy-breach and excavated the attack by providing both-way access to the confidential database resulting in increased attack surface for the adversary (Student No. 24)

Further, many students give their opinions on possible solutions to deal with AI security issues. Mainly two directions are mentioned in students' reflections. The first one is managing the AI security issues with mature and strict regulation, for example, law.

The most important thing for humans to prevent such tragedies from happening is to form appropriate regulations and guidelines for AI development. Already many countries and organizations have launched some guidelines, and the number will increase over time. If those regulations and guidelines are well-kept, and the AI stays under the control of humans, we will have a better chance of avoiding the situation we saw in the movie (Student No. 23).

The second one is managing the AI security issues with advance technology, for example, developing a monitoring system.

I learned that there are still a lot to be done to keep artificial intelligence safe. We might need some cybersecurity breakthroughs to keep the data unhackable. It was clear to me that there are some flaws in AI but I had never thought that seemingly good weak AI might also withhold pernicious traits (Student No. 19).

AI in reality

Students are able to connect the content of the SF story with what is happening in reality. 13 pieces of content from students' answers are marked with the code "AI in reality".

Nowadays big companies like Google or Apple develop powerful programs for face and speech recognition, analyzing big data or self-driving cars. These algorithms are used to create personalized advertising, support people in their daily life or just for the seek of research. So, mostly these are actually good or, let's say "all right" reasons. But what happens if a democracy changes to a dictatorship like the one of Hitler in Germany on today? In which way might such people misuse for instance AI used for face recognition or the collected metadata from Google. (Student No. 1)

Another point in the episode was mass surveillance: in my opinion, a world where some necessary artificial intelligence is secretly or openly used by the government to collect data and spy on the population feels dystopic. Even if Europe generally protects people, for example, from being constantly monitored through cameras while at work, other countries might actually consider monitoring society. (Student No. 26)

Compared to the killing AI bees, these are much closer to our reality. The home intelligence is there already. With the functions of brightness adjusting and automatic switching, home devices act in a similar way with what we have in our lives. (Student No. 41)

AI in other materials

Watching *Hated in the Nation* also let the students think of other materials related to AI, such as news, other SF stories, as well as books.

My understanding is that China already has automated facial

recognition in public cameras which are used to automatically identify, fine, and publicly shame people for jaywalking and other traffic violations
(<https://www.independent.co.uk/news/world/asia/china-police-facial-recognition-technology-ai-jaywalkers-fines-text-wechat-weibo-cctv-a8279531.html>). (Student No. 11)

Or like recently on the second season (Spoiler alert) of Star Trek: Discovery, where a humanoid-built big data decision-making system gains “consciousness” and turns against its human creators. Of course, Artificial Superintelligence (above current human capabilities) has been a recurring theme throughout several different Star Trek series. (Student No. 34)

Again, using some information from Max Tegmark’s book Life 3.0 future AI applications need to be, first, secure but also in a way transparent meaning nobody should get that kind of backdoor access that was seen on the episode, not even a government. (Student No. 18)

AI in the future

Some students try to explore the possible situation of AI in the future.

But from the movie, it was clear that the literacy and ability to understand machine language and data science will become even more normal and prevalent and necessary by that time (just like the lady detector in the movie who had the ability to detect and track the data). (Student No. 5).

Another point is that employees in different fields will have to face new challenges due to the change AI brings. It is nothing new that malware has been challenging for computer scientists in the past and

that mistakes in programming are often detected only because an attack happened. The new thing will be that the damage is done might be physical and e.g. the police, the accident ambulance or secret services will have to come up with new strategies of protection. Especially at the beginning of the process, governmental services might not be prepared enough. (Student No. 31)

Logic behind the content of *Hated in the Nation*

As we have discussed previously, SF is not originally created for spreading correct science or technology message, but mainly for entertainment. Hence, many SFs do contain wrong or misleading messages. However, discussing the possibility of the technology and the validity of the logic that appears in SFs is interesting. From students' answers, we also found some of them try to understand and explain the technology theory and logic behind the story, while also some of them discuss the invalidity of the story. For example, Student No. 20 explains how the criminal changes the algorithm in order to use the ADIs to kill the targeted person:

Most likely the command given to artificial bees was "GO HOME" and the new address of "home" was given. As long as AI is thought to do simple tasks efficiently (as those are), they are not having wider consciousness of if the task they do might be harmful. Changing the parameters of sensors in the video can make the bee to see a human as home.

Student No. 29 explains, how the ADIs could find the targeted victim by tracking the victim's phone:

The rule-based part made the bees navigated to the person who got most "death to" tweets based on his/her phones imei code and penetrated that person's brains. Pictures attached to the tweets were used for teaching the machine learning algorithm so that the bees could recognize the face of the subject.

The information about how the ADIs find the victims is actually explained by the main characters as the story develops. However, the audience needs to be careful and also think constantly to find out the answer. Some of the students have questions about how the ADIs could find the location of the victims.

Like the bees had pattern recognition which would explain how they could find targets but how could they find them if they are somewhere far away from where they can't be seen? (Student No. 22)

The video had some unexplained or unrealistic parts though, as the bees always knew where the target person's position was, even though they were behind walls and had not been seen by bees (Student No. 32).

Student No. 3 finds the setting of Hated in the Nation unrealistic for the following two reasons:

The first being that the AI system used was, although it would be a very complex system to build, build on a very simple premise. The bees followed only a very basic set of rules to recognize what they think is a flower and fly from one to the next. The impressive part was, as in an actual beehive, the sheer scale of the entire system and the swarm intelligence used to independently reproduce and spread over a huge area.

Secondly, the system worked as intended over the course of the whole episode. The problem is that it was altered with malicious intent. The system was even designed safe enough that only single bees could be hacked only with insider knowledge and within close proximity. Even the security breach that caused nationwide failure wouldn't have been possible without human error.

Students No. 20 also expresses his/her doubt to one setting of *Hated in the Nation* as shown below:

In the video, bees were made self-sufficient, such as those build new members of the bee-family with exponential growth. If each bee has some calculation power, it would have meant that most of the calculating power on the earth would be within a rather short time in AI-bee family. As such those has no limit on power (solar power), no limitation on labour and no limitation on resources.

In addition to analyzing the five popular themes that appear in students' reflection, this research tries to find out if students are able to identify the AI technologies and applications that show up in *Hated in the Nation*.

20 students mention the AI technologies and applications they identify from *Hated in the Nation*. These technologies are unsupervised learning/self-learning (2 students), facial/image recognition (13 students), deep learning, machine learning (2 students), neural network, self-driving car (3 students), reinforce learning, the weaponization of AI, narrow AI, weak AI (2 students), symbolic AI (2 students), geo-tagging, self-preservation, recreation, risk-analysis, emergency shutdown, procedures, automatic light, and intelligent home.

Students are also able to connect the content of *Hated in the Nation* with the knowledge introduced during the course. 22 piece of content collected from 15 students' answers are identified that the students have explicitly mentioned that the content in *Hated in the Nation* could be associated with the knowledge introduced in the course. For example:

Relating this to what we have learnt during the course, I would like to talk about how contacts and locations of victims were known. This shows the use of data science to store data of the individuals. Some

included representing data by encoding them to numbers. The use of facial recognition by the ADIs also the activity of neural networks according to what we have learnt over the course. (Student No. 4)

As was presented during the course, AI does only the things we program them to do, but if control lands in the wrong hands, AI like any tool, such as a blunt instrument, can be used to cause harm. (Student No. 12)

This is an example of using AI for evil purposes. There are also some articles discussing autonomous drones and tanks using in the war to destroy targets which are called the weaponization of AI (Solin 2019). (Student No. 14)

As we have introduced before, discussing the AI security and who should take the responsibility of AI security are two sub-themes frequently appear in students' reflection. These two sub-themes are also topics that the course has discussed.

Solin (2019) has discussed the ethics of AI, in which he mentioned about the four pillars to evaluate AI systems, including fairness, robustness, explainability, and lineage. Moreover, Isaac Asimov's Three Laws of Robotics was also discussed. These mentioned things should be strongly considered as building an AI system. (Student No. 14)

On the last lecture one of the topics was ethics and who is responsible for bad things made by AI. In this case, it is very clear that it was the developer's fault because AI itself didn't make the decision because it was rule-based AI. (Student No. 29)

"Who is responsible for the action of AI?" Certainly, it has become unclear how should we tackle if there are issues in AI operations. We

cannot blame a thing to be responsible for its cause. Like being manipulated wrongly in the video, the man can easily kill people without physical involvement, and we should be aware of how dangerous if the AI technology falls into wrong hands. (Student No. 37)

4.2 Synthesis of the case study

In this subchapter, the findings in subchapter 5.1 are reorganized. The findings are classified as the following three categories: benefits, challenges, and applications. The benefits category describes the benefits of including watching *Hated in the Nation* as a part of the course of IAI. The challenges category describes the disadvantages and potential problems of including watching *Hated in the Nation* as a part of the course of IAI. And the applications category describes, how the content in *Hated in the Nation* could be used in the course of IAI. A synthesis presented the findings of this empirical research is shown in Figure 11. The content of this synthesis is also explained in the following sections.

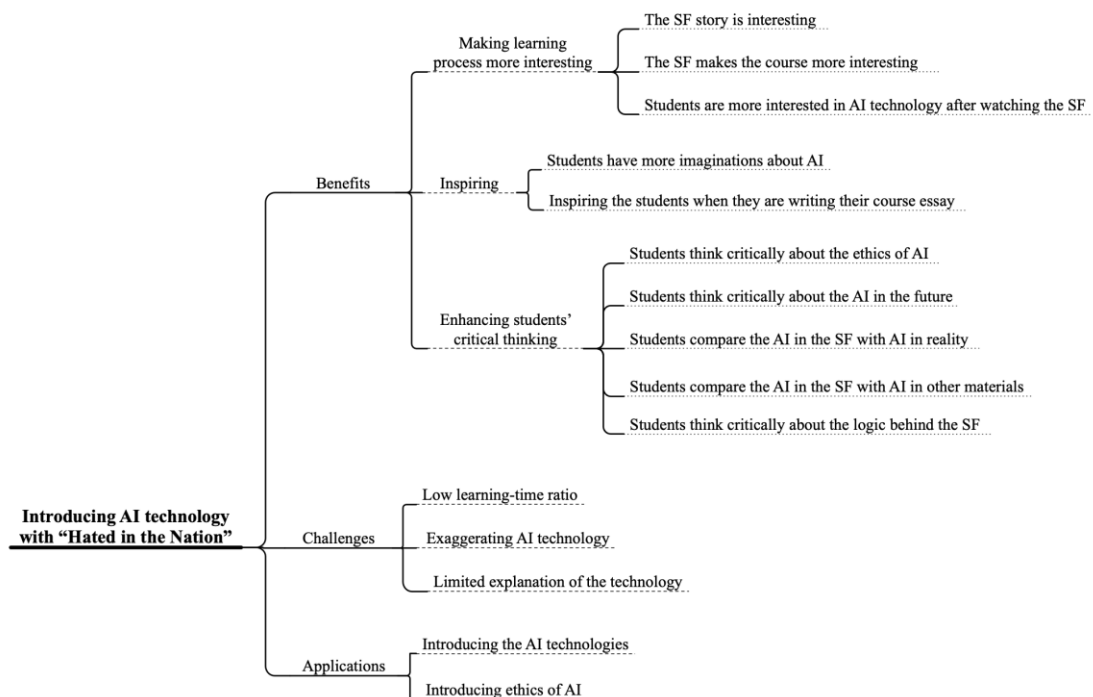


Figure 11. Synthesis of the case study.

4.2.1 Benefits of including *Hated in the Nation* as part of the course

As shown in Figure 11, the benefits of watching *Hated in the Nation* for students can be summarized as three points. The first benefit is making the learning process more interesting. Making the learning process more interesting is demonstrated from three perspectives: the story itself is interesting, the content of the story also makes the topics of the lecture more interesting for the learner, and students feel more interested in AI technology after watching the SF. These statements are proved by the result of the questionnaire.

The second benefit is watching *Hated in the Nation* inspires students from many perspectives. On the questionnaire, the students agree that watching *Hated in the Nation* inspires their imagination about AI, and also gives them new ideas for writing the course essay. Except for students' answers to the questionnaire, the rich content of the answer to the open question is also a strong demonstration of the inspiring benefit.

The third benefit is that watching *Hated in the Nation* could enhance learners' critical thinking. In this case, the result of analysing the answers to the open question shows that the students are able to 1) think critically about the ethics of AI, 2) think critically about the AI in the future, 3) compare the AI in *Hated in the Nation* with the AI in reality, 4) compare the AI in *Hated in the Nation* with the AI in other materials, 5) think critically about the logic behind *Hated in the Nation*. Especially, *Hated in the Nation* strongly enhances critical thinking about the ethics of AI is strongly enhanced. On the questionnaire, students strongly agree that *Hated in the Nation* helps them think critically about the ethics of AI. Besides, while answering the open question, 41 out of 44 students identify and discuss issues related to the ethics of AI.

4.2.2 Challenges of including *Hated in the Nation* as part of the course

In this case, the challenges of including *Hated in the Nation* to the teaching process are identified as, first, having a low learning-time ratio, second, exaggerating the AI technology, and third, limited explanation about AI technology (shown in Figure 11).

All of these challenges could easily be identified by students. Relevant comments could be found from students' answers to the open question.

A low learning-time ratio is due to the video has a low knowledge-density. The video tells a complete story in 90 minutes. It contains many contents irrelevant to AI technology, so content directly about AI technology is limited. Thus, students need to spend extra time to also watch the content irrelevant to AI technology to gain useful information. The video describes a story happen in the near future, so the AI technology and product in the story are imaginary according to the AI development nowadays. Some of the settings are plausible, while some other settings are doubtful. Further, *Hated in the Nation* seldom explains the AI technology behind. The video focuses more on the phenomenon that a new AI invention brings to society, rather than the technology itself. SFs tell stories and focus more on social phenomena is common. Technology principles could be the background of the stories. Students also mention other SFs which explain technology more than *Hated in the Nation*.

4.2.3 Potential applications of *Hated in the Nation* in teaching

Hated in the Nation could be used to both introduce the ethics of AI and AI technologies. Students strongly agree that watching the video helps them both understand and think critically about the ethics of AI. And the students demonstrate that they are eager to discuss the ethical issues while answering the open questions. For teaching the AI technologies, students only slightly agree that watching the video helps them understand the technology of AI, but still students agree that using the video to present/learn AI technology is helpful. The video does explain some technical principle, and show plausible AI invention. But such information is relevantly limited and more challenges to discover compare the ethics issues. Using the video to present AI technologies may require lecturers to spend more time to prepare relevant materials and explain the relevant technologies shown in the video. Overall, students have a positive attitude to including *Hated in the Nation* as a part of the course IAI, and many positive comments are received.

5. Discussion

The main conclusions are presented in this chapter. First, both theoretical and practical implications are discussed. After comparing the results of the empirical research and the theoretical framework, a revised theoretical framework is suggested. General advice of course design is given for technical and scientific courses, and also specific advice is given for organizing the course IAI in the future. Then the quality of the research and the challenge of future study are discussed. Finally, a summary of conclusions is given as the end of this thesis.

5.1 Applying Science Fiction to Course Design

5.1.1 Students' attitudes and learning when using SF

In this section, the third part of the theoretical framework (Figure 4) and the synthesis of the case study (Figure 11) are compared. While comparing this study's findings with the earlier studies, both similarities and differences could be found. First, the benefits are compared. The theoretical framework shows that learning with SFs could add interests to learning activities and enhance critical thinking. These two benefits are also identified directly from the case study. And the synthesis of the case study further shows how these two benefits are presented in practice.

The findings of the study indirectly show that the use of SF increases learners' learning motivation. According to the classic intrinsic and extrinsic motivation theory, if the nature of the learning process is interesting, a learner will have a high intrinsic motivation (Ryan & Deci, 2000). In another motivation theory, the ARCS model of motivation consists of four components: Attention, Relevance, Confidence, and Satisfaction (Keller, 2000). Attention refers to the learners' interests (Keller, 2000). Relevance means that the learning process should show the usefulness of the content so that learners can bridge the gap between the content and the real world (Keller, 2000). The synthesis of the case study confirms that learning with the SF both add interests to the learning process and enable the students to discuss AI in reality and in other materials.

Two other benefits left shown in former studies that are increased learners' engagement and longer-remembered knowledge. The case study does not allow to test these two arguments, so these two arguments are neither supported nor denied by this case study. Students watch the SF after all the lectures, and all the lectures do not include activity related to the SFs because participating in this research is voluntary, and not all the students who enroll in the course IAI watch the selected SF. Hence, in this case, the engagement level could not be observed. Also, whether students remember knowledge gained from the SF longer time than knowledge learnt by lecture and other traditional learning materials was not tested. A new benefit is identified in this study is that students are inspired by *Hated in the Nation*. They have more imaginations about the possibility of AI technology, and get new ideas for writing their course essays.

The first challenge indicated in the theoretical framework is lecturers need to integrate SFs with the curriculum before using them as teaching materials. Even though this challenge is not reflecting in the synthesis of the case study, it happens during the research process. In order to finally choose one SF that could better match the teaching content, more than 30 SFs have been watched and analyse before *Hated in the Nation* is selected as the case study material. This selection process is time-consuming. The second challenge identified by previous studies is lecturers need to reorganize the content of SFs to fit teaching requirements. An SF movie or a novel is usually too long to be fit in one teaching section, so lecturers should shorten the story and only keep the most relevant information (Bixler, 2007). This challenge is shown in this study as "low learning-time ratio". Because the knowledge density in *Hated in the Nation* is relatively low comparing to formal teaching materials. Students need to spend extra time to understand, for example, the setting of the SF story. The third challenge mentioned in former studies is that SFs often include misleading information. In this study, this challenge is shown as the SF contain exaggerating AI technology. Some students find that some AI technology or AI invention is too advanced, so unrealistic. A new challenge identified in this study is that *Hated in the Nation* has a limited explanation of AI technology. Many

other SFs might also have the same problem. Lecturers should be careful when selecting SFs for teaching.

Three applications of using SFs in teaching are introduced by previous researchers. Using SFs to introduce science theories is not in the scope of this case study, because the course IAI is for teaching AI technology, not scientific theories. The other two application, introducing technology principles and introducing ethics of science and technology development, are supported by the results of this case study.

From the discussion above, the findings from the case study are highly coherent with the findings from previous studies. However, several findings (two benefits, one challenge and one application) from previous studies are not tested in this case study, so neither support or reject evidence found for them. In addition, a benefit and a new challenge in teaching with SFs are identified in this case study. A new synthesis is generated by both the findings from the previous studies and the current case study, and it is presented in Figure 12.

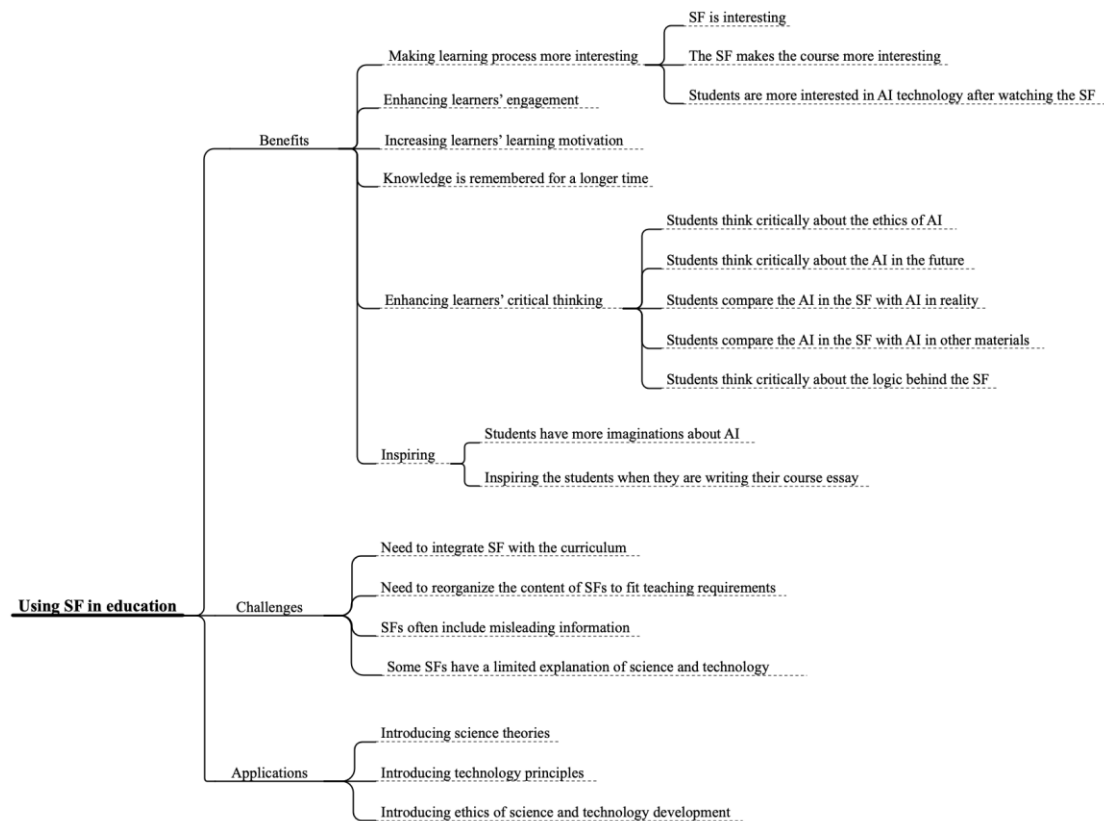


Figure 12. Theoretical synthesis of using SF in education.

5.1.2 Using SF in an AI course

This study has several practical implications. First, the results of the case study prove that *Hated in the Nation* could be a good material for both presenting AI technologies and teach the ethics of AI. In general, including *Hated in the Nation* as an additional learning material makes the learning process more interesting, enhances learners' critical thinking, and inspires the learners for writing their course essay. Second, lecturers could let students watch *Hated in the Nation* before teaching the topic of ethics of AI to create the engagement of students. *Hated in the Nation* gives very good background materials for discussion. In the case study, students showed a high willingness to discuss the ethics of AI after watching the SF. These discussions could be brought to the lecture and hopefully enhance the engagement level. Third, some of the AI technologies appearing in *Hated in the Nation* are too advanced and unrealistic. Such exaggerated or misleading contents could be identified and discussed in a lecture. Or it could be designed as an

independent assignment to ask students to identify the unrealistic AI technologies that appear in the SF. For example, the ADIs are designed to be able to self-reproduce, but where and how the ADIs find the materials for reproduction is questionable. Fourth, except for watching the whole SF, a lecturer could also make a summary of the SF or show a few clips that most relevant to the teaching assignments to the students. The form of showing the SF depends on how the SF would better support the teaching plan, for example, how much time would be spent on discussing the SF. If a summary or a few clips of the SF are given on the lecture, students who are interested in the SF could watch the whole video voluntarily by themselves. Fifth, except *Hated in the Nation*, many other good SF materials about AI could also be considered for teaching. Lecturers could try to use other SFs to replace *Hated in the Nation*, or introduce more SFs to the lecture to introduce various topics related to AI.

The result of the case study also sheds light on computer science courses in general, as well as technical or scientific courses. Teaching with SFs is useful for students to get a big picture of a technology or a scientific theory. Therefore, it is more suitable for teaching entrance-level students, for example, junior students having their major in engineering, technology or science; or courses for students with non-technology backgrounds who also need a basic understanding about some technologies, such as business students who might work for technology-oriented company, or law students study regulations of technology development. For the technical or scientific courses targeted in senior students, SFs might have limited effects on improving the teaching outcomes, but SFs could always be used as an open-up for the course to add interest to the learning activities.

5.2 Evaluation of the quality of the study

One universal problem of case study is that the result is for a specific case, and cannot be generalized directly as a universal theory. However, most scientific research needs to be replicated multiple times before a reliable conclusion is drawn

(Gray, 2004b). Similarly, a result drawn from a single case study may have limited value for other cases in practice. However, if a common structure could be found from multiple case studies, and the results drawn from different case support each other, general principles could be found. Further, the result drawn from this case study is similar to the findings from previous studies, even though the teaching subjects are various. On one hand, the result of this case study re-confirm the findings of previous studies. On the other hand, the reliability of the result of this case study is supported by previous studies.

When measuring the students' interest level and attitudes to the new teaching method, a questionnaire was used for students as self-reports. This is generalized from a common approach for measuring intrinsic motivation. A self-report is common for measuring interest and enjoyment of the activity.

In this research, information is gathered on time, so the accuracy of students' memories is guaranteed. The study is conducted along with the course IAI. When participating in the research, students have fresh memories of the knowledge and the learning experience. This helps them to accurately report their feelings and precisely report their opinions.

One of the limitations related to qualitative analysis is the risk of misunderstandings. Text materials are analysed in this case. Face to face communication or in-depth interview is lacking. The researcher tries to understand the students' opinion only through the text written by students. The researcher does not have the opportunity to ask students questions when the text is not clear, and the students cannot clarify themselves with further explanations.

Knowing the literature might bring an unavoidable bias to the result of the study. The researcher already learns theories from previous studies. When the researcher already has certain opinions, existing theories are now considered when analysing the new case. This may introduce biases to the analysing of data.

Another bias of this research might be that students that voluntarily participate in this research might originally be more interested in SF, so they are more likely to give positive responses. In other words, if participating in the research is mandatory for all the students from the course IAI, more negative results might be received. However, it is understandable that a teaching method may be more suitable for a group of students, and not that suitable for another group of students. Students in universities have a high level of freedom to choose courses which are more suitable for them. If there are students interested in learning technology and science with SFs, courses with the new teaching methods could be organized.

5.3 Future research challenges

Suggestions for possible research in the future are given at the following. First, as mentioned in the previous subchapter, research results from a single case study are difficult to be generalized. Thus, similar research should be done in the future, and the results from independent cases could be compared in order to find generalized principles of using SFs in teaching. Especially, computer science is a broad subject, many interesting and promising technologies are developing in this field, for example, the blockchain technologies, quantum computer, holography, etc. Similar research could be done for teaching these technologies.

Second, research including all the students in a course could be done in the future to gather more general information. In this research, only the opinions of the voluntary students were gathered, so the results might be biased since the voluntary students might be originally more interested in SFs, and more willing to give positive commons.

Third, from the result of this research, courses teaching technical and scientific knowledge at an entrance-level benefit more from using SFs. Future studies could focus more on entrance-level courses in technology and science. Or a comparison study could be done to compare the effects of using SFs in an entrance-level course

and in an advanced course. Similarly, a comparison could also be done between students with technical backgrounds and students with non-technical backgrounds.

Fourth, a further study could be conducted to compare the study outcomes of learning with SFs and learning without SFs. For example, whether students learning with SFs get higher scores than students learning without SFs? Or whether students learning with SFs understand the technology concept better than students learning without SFs?

Fifth, from the existing studies, teaching with SFs show both benefits and challenges, and each of the benefits and challenges could be investigated along. When research is conducted with a smaller focusing point, more precise questions could be asked in the questionnaire, or deep interviews could be conducted to have a deeper understanding of how SFs affect students in a specific perspective.

Sixth, finding good SF materials for teaching is challenging. If lecturers plan to include SFs as teaching materials, they need to find suitable SFs according to the teaching content by themselves. A checking list that includes good quality SFs containing knowledge in a specific field would be useful. Thus, analysing contents of SFs, testing validation of hypothesis in SFs, and investigating plausible theories appear in SFs can also be the work of future researchers.

6. Conclusions

Based on the results of the case study, the benefits, challenges and applications of using SFs in teaching AI technology are summaries in Figure 11. The results of the case study are then compared with the third part of the theoretical framework. Most of the findings in the case study are supported by the theoretical framework. The results of the case study could be seen as a practical reflection of the theory. Besides, new findings lacking from previous studies are also identified in the case study. The case study identified a new benefit: SFs could inspire students imagination about technology and help them get new ideas for writing; and a new challenge: some SFs might have limited explanations of technologies or science. Thus, a revised theoretical framework is suggested after considering the result of the case study. And the revised theoretical framework is shown in Figure 12.

According to the empirical findings, it can be concluded that, first, students have positive attitudes to using SFs in AI teaching; and second, the SF supports students in learning AI at an entry level by making the learning process more interesting and stimulating students' reflection. Students would like to include SFs materials both in the course IAI and in other courses that introduce technology concepts and scientific theories. Watching *Hated in the Nation* makes students both more interested in the course IAI and the AI technology in general, so the students become more motivated in learning subjects related to AI. Watching the SF stimulates students' reflections both on the AI technology itself and on the ethics of AI. Students are able to apply the knowledge learnt from the lecture to analyse the logic of the SF, compare the AI appear in the SF with the real AI in our lives, and also discuss the possible development of AI in the future. Ethics is a complex topic for teaching, but when students are asked what do they learnt from the SF, they show great interests in the ethics of AI and are able to give rich reflections on it.

According to the theoretical and empirical findings, it can also be concluded that as a teaching material, SFs support students' learning process in two perspectives. First, different from traditional teaching materials, for example, papers and textbooks, SFs

transfer knowledge in an interesting way. SFs put knowledge in a specific context, connect technologies and science with our lives and make them relevant to us. Though SFs usually contains some unrealistic technologies or fictional scientific theories, these wrong information also provides opportunities for students to apply the knowledge they learn from lectures to analyse and decide whether the logic and the hypotheses in an SF are plausible or invalid, so students' critical thinking could be improved. Second, by watching SFs, students build emotional connections with technology and science. Seeking meaning is a natural and important behaviour of human beings. For learners, knowing the meaning behind the subject they are learning is significant, and it is the meaning support their learning behaviours in the long term.

Overall, the results of the study encourage educators using SFs to introduce technology concepts and science theories at entry level, and also using SFs to teach ethics related to technology and science development. Which needs to be clarified is that SFs should be used as additional materials to increase the diversity of teaching activities and increase learners' interests in learning. SFs are not a replacement of formal and traditional teaching materials.

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Appendixes

Appendix A: User Survey for the Research Study of Applying Science Fiction to Course Design--A case of computer science

4/21/2019

<https://www.webpolsurveys.com/Answer/SurveyParticipation.aspx?SDID=Fin1746883&SID=ac79d5ca-438f-4b14-8851-48bbe5497007&dy=9...>



User Survey for the Research Study of Applying Science Fiction to Course Design--A case of computer science

Consent: please select your choice.

I understand that the information collected in the Research Study will be used for the purposes described in the Privacy Notice (<https://1drv.ms/b/s!Atsf2X1ydWRbKyYHAG304DH2AI>.) *

Yes

I have been given the opportunity to ask questions about the Research Study. *

Yes

I agree to participate and I understand that my taking part is voluntary; I can withdraw from the Research Project by notice sent to xuan.ma@aalto.fi. However, all information that has already been anonymized before withdrawal, may be used for purposes described in the Privacy Notice. *

Yes

I give permission to use citations from my survey answers in research publications. *

Yes

I give permission to use citations from my enclosed course essay in research publications. *

Yes

I give permission to use my score of the course and the course essay that I choose to provide as research data for the study. *

Yes

Next -->

<https://www.webpolsurveys.com/Answer/SurveyParticipation.aspx?SDID=Fin1746883&SID=ac79d5ca-438f-4b14-8851-48bbe5497007&dy=938959446>

1/1



User Survey for the Research Study of Applying Science Fiction to Course Design--A case of computer science

Part 1. Personal information

1.1 What is your student number? (This information is collected for matching your answer to this questionnaire with your answer to the later questionnaire, as well as giving extra points to your course essay.) *

1.2 In case the research will need further interviews for better understanding the result, may I contact you? *

- Yes
 No

1.3 What is your email address? (This information is collected for contacting the winners of the raffle and those for possible interviews regarding this research.) *

1.4 What is your background? (Please fill in your major or professional field.) *

1.5 What is your age? *

1.6 Did you watch the selected video "Hated in the Nation" before the last lecture? *

- Yes

4/21/2019

<https://www.webpolsurveys.com/Answer/SurveyParticipation.aspx?SDID=Fin1746883&SID=ac79d5ca-438f-4b14-8851-48bbe5497007&dy=9...>

No

1.7 Did you finish your course essay? (Please answer this questionnaire only after you watched the video and finished your course essay.) *

Yes

No

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<https://www.webpolsurveys.com/Answer/SurveyParticipation.aspx?SDID=Fin1746883&SID=ac79d5ca-438f-4b14-8851-48bbe5497007&dy=938959446>

2/2



User Survey for the Research Study of Applying Science Fiction to Course Design--A case of computer science

Part 2. On a scale from 1 to 6, please rate your response to the following questions. (1 = extremely agree, 2 = moderately agree, 3 = slightly agree, 4 = slightly disagree, 5 = moderately disagree, 6 = extremely disagree. There is no option of neutral, please choose the option which is closest to your attitude.)

2.1 I enjoyed watching the video "Hated in the Nation" for the course of Introduction to Artificial Intelligence. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.2 The video reminded me of the knowledge I learned in the course. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.3 Watching the video made the content of the course more interesting to me. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.4 I was able to think about the technology of AI while watching the video, applying course materials to the concepts presented in the video. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.5 Watching the video helped me understand the technology of AI. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.6 Watching the video helped me understand the ethics of AI. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.7 Watching the video helped me think critically about the ethics of AI. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.8 I think that using the video to present/learn AI technology is helpful. *

1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.9 The video made me be more interested in the technology of AI. *

- 1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.10 The video inspired my imagination about AI. *

- 1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.11 I think I would like to see some science fictions as learning materials in other courses that introduce technology concepts. *

- 1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

2.12 The video gave me some inspiration for writing my course essay. *

- 1 = extremely agree 2 = moderately agree 3 = slightly agree 4 = slightly disagree 5 = moderately disagree 6 = extremely disagree

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User Survey for the Research Study of Applying Science Fiction to Course Design--A case of computer science

Part 3. Open questions

3.1 Could you list three topics you learnt from the lecture which also appeared in the video? *

3.2 Where did the video go right? Could you give one example and shortly explain why? *

3.3 Where did the video go wrong? Could you give one example and shortly explain why? *

3.4 Except answering the additional question, did you mentioned the video "Hated in the Nation" in your course essay? *

3.5 Except answering the additional question, did you mentioned other science fictions in your course essay? If you did, what are the names of the science fictions you mentioned? *

3.6 Please upload your course essay here. *

You can attach one or more files from your computer to your response. To attach a document, click Browse and browse for the file. Select the file and click Open. To delete a file, click on the trash bin

4/21/2019

<https://www.webpolsurveys.com/Answer/SurveyParticipation.aspx?SDID=Fin1746883&SID=ac79d5ca-438f-4b14-8851-48bbe5497007&dy=9...>

icon.

No file chosen

3.7 Any other thought?

[<-- Previous](#) [Submit](#)

Appendix B: Privacy Notice for A Research Study of Applying Science Fiction to Course Design - A case of computer science

Privacy Notice for A Research Study of Applying Science Fiction to Course Design —A case of computer science

1. Purpose of the research study

The research explores whether science fictions contain legitimate science and technology knowledge and whether learning with science fiction materials brings additional benefit to students compare to only learning with traditional materials. The research aims to analyse the legitimacy of technology and ethics concepts about Artificial Intelligence in a selected science fiction story "Hated in the Nation", and to test whether students learn better with this selected science fiction material.

2. Participation is voluntary

Allowing use of the following information is voluntary, including the answer of the questionnaire, the score of the whole course CS-C1000 - Introduction to Artificial Intelligence, the course essay and the score of the course essay. Participation can be discontinued at any time by contacting xuan.ma@aalto.fi. Should you discontinue to allow the use of your information all materials and personal data related to you will be deleted and not used in the research study. Anonymised information is no longer personal data.

3. How data is collected?

From the students that choose to volunteer to this research study the following information is provided by the students: scores of the course essay and scores of the whole course CS-C1000 - Introduction to Artificial Intelligence. Students are also asked to provide a copy of their course essay.

Student volunteers' answer of the questionnaire will be collected through Webropol surveys. In order to better understand students' learning process, collecting data through face to face interview or online interview is also possible.

4. Sources and categories of research data

All the data are voluntarily provided by students. The categories of data include answer of the questionnaire, the course essay, the score of the course essay and the score of the whole course CS-C1000 - Introduction to Artificial Intelligence.

5. How personal data is used

Data is only used for the research study of Applying Science Fiction to Course Design--A case of computer science, for testing whether learning with science fiction material help students better understand science and technology and for understanding students' experience of using the science fictions in courses that introduce science and technology knowledge.

Data is stored during research in an encrypted laptop, encrypted with Bitlocker. The data containing scores is deleted immediately after analysis. Citations from survey answers and essays may be used in research publications. Other personal data is deleted after the research study is completed.

6. Legal basis

We do not expect the processing to affect data subjects in any way.

The research study aims to analyse the legitimacy of technology and ethics concepts about Artificial Intelligence in the science fiction story: Hated in the Nation, and test whether students learn better with this selected science fiction material.

The legal basis for processing personal data is the consent of the data subject.

7. The rights of the study participant and the exercising of your rights

The data subject is the student participant of the course CS-C1000 - Introduction to Artificial Intelligence, which is organised at Aalto University, during the 26th of February to the 5th of April, 2019, who has volunteered to take part in the research study. The data subject has the following rights during the research and analyzing of the material:

- The right request access to data
- The right to object to processing the data
- The right to rectify information
- The right to request restricting of processing
- The right to request removal of personal data

Because data is being processed for the purposes of scientific research, the data is not used in decision-making related to the data subject.

8. Sharing of personal data

Personal data will not be shared outside of the use for research study Applying Science Fiction to Course Design--A case of computer science.

9. Transfer of your data to non-EU/EEA countries

Personal data will not be transferred outside EU. Names or direct identifiers will not be published, only the anonymized results of studies will be published, unless the student gives his/her consent for citations of survey answers and course essays.

10. Measures taken to protect your data

The following measures are taken in this research study to protect your rights:

- The research study has a research plan.
- The person responsible for the research study is: Xuan Ma
- The supervising professor is: Matti Vartiainen

11. The Controller

The controller in this study is Xuan Ma

Contact information: xuan.ma@aalto.fi

The research data subject can contact Aalto University's Data Protection Officer if they have questions or demands related to the processing of personal data, phone number: +3580947001, Email: tietosuojavastaava@aalto.fi.

If the research data subject sees that their data has been processed in violation of the general data protection regulation, the data subject has the right to lodge a complaint with the supervisory authority, the data protection ombudsman (see more: tietosuoja.fi).

Appendix C: Instruction for Research Participants

Instruction for Research Participants

Step 1: watch a selected science fiction video

- What: **Hated in the Nation** (*Black Mirror* Season 3, episode 6)
- When: before the last lecture, 5th of April
- Where: on Netflix (if you are a new user of Netflix, you get one-month free service), or any other ways. (* In case you have a problem to find the video, let me know, and I will let you find it.)

Step 2: on your course essay, mention the video if you want, in any way you feel comfortable

- In your course essay, you will be required to reflect your own thought. And you might need some example to explain it. For example, I might want to talk about the face recognition technology which could be dangerous if somebody uses it in an improper way. Then I would give an example to explain, what kind of improper way, and what kind of result it might bring, and maybe further, how to prevent it. I may find several scenes in the video similar to my idea, so I could use them as examples in my essay. Of course, this is just one way to do it. Feel free to explore some other ways to use it. I am sure that you can do it in many other creative ways. Feel free to say anything or do not say anything about the video in your essay.
- In case that, you would like to mention other science fictions in your learning diary, you could also tell me the name of the movie in the questionnaire

Step 3: answer an extra question: what did you learn about AI from the video? Describe how does it relate to the topics of the course

- In about half-page long (about 150 to 200 words)
- Submit your answer with your course essay.

Step 4: fill in the first questionnaire (10 minutes)

- After you finish your course essay.
- The questionnaire will be posted on MyCourses on 5th of April, after the last lecture of the course *Introduction to Artificial Intelligence*.
- Please also upload your course essay to this questionnaire, as I do not have the right to access your course essay through MyCourses.
- Link to the first questionnaire: <https://www.webropolsurveys.com/S/81FB974967DCC871.par>
- Deadline: 20th of April, 23:59

Step 4 + 1: fill in the second questionnaire (2 minutes)

- Please fill in your scores of the course essay and the whole course Introduction to Artificial Intelligence in this questionnaire (**without the 6 extra points**), as I do not have the right to access any of your scores through MyCourses.
- Link to the second questionnaire: <https://www.webropol-surveys.com/S/AAE777B3430462AC.par>
- Deadline: the second questionnaire will be closed few days after your final grade of the course available in MyCourses, please fill in your the second questionnaire when you know your scores as soon as possible. Will inform you the deadline later.

By accomplishing these 4 + 1 steps, you will get:

- Fresh ideas for your course essay while adding some fun to your study
- Extra points in your final grade of the course *Introduction to Artificial Intelligence* (Amo will let you know how many points later)
- Raffle for movie tickets: 10 tickets for 5 of you

The background information about the research can be found on the slides which are presented on 26th of March. The slides are also posted on MyCourses.

Many thanks for your interests and helps. If you have any question regarding the research, welcome to contact me by email.

Contact: xuan.ma@aalto.fi