Machine Learning- An Educational Revolution?

A Scenario Analysis of the Future Role of Machine Learning in the Public Primary School in Gothenburg

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Abstract

The Swedish students' results have gradually decreased in international comparisons, wherefore the educational industry is experiencing an augmenting pressure for change. Simultaneously, the demand and supply of tools based on the Machine Learning (ML) technology is beginning to augment within the educational sector. However, due to the scarcity and ambiguity of research regarding the outcomes of digitizing the educational sector, industrial changes occur slowly, even though the technology of ML has the potential to disrupt the educational industry.

The purpose of this research has been to study the role of ML within the field of the public primary school in the city of Gothenburg in the coming five years by using the framework of Scenario Planning. The study was conducted by identifying trends that will influence the future role of ML and their level of impact, uncertainty and correlation. The research employed mixed methods by conducting and analyzing qualitative interviews supported by a quantitative survey including a broad spectrum of stakeholders active within the industry of ML, Educational Technology (EdTech) and the public primary school in Gothenburg. This resulted in 11 identified trends, acknowledged to affect the future role of ML. Eight trends were identified as certain and three as uncertain. Based on the trends, four scenarios were developed.

This study concludes that a widespread diffusion of the ML technology in the public primary school in Gothenburg will not occur within a five-year period. However, the future development of the technical infrastructure and the availability and comprehensibility of knowledge and research will greatly impact the future role of the ML technology. Lastly, an extensive knowledge gap has been identified between the schools' needs and the companies' supply, which might decrease with increased knowledge and with regulations focusing on solving fundamental difficulties currently present in the Swedish schools.

Key Words: Scenario Planning, Machine Learning, Public Primary Education, Trends, Uncertainties

Abbreviations and Definitions

AI- An abbreviation of Artificial Intelligence, meaning the art of machines with the ability to replicate thinking, make decisions, solve problems, learn and act in ways normally associated with humans.

ML- An abbreviation of Machine Learning, meaning a program or system that builds a predictive model from input data. ML uses the learned model to make useful predictions from new data drawn from the same distribution as the one used to train the model.

EdTech- An abbreviation of Educational Technology.

Digital Tool- An instrument used in school for administrative and/or pedagogical tasks, e.g. laptops, tablets, and applications. Referring to both software and hardware.

Scenario Planning- A long-term strategic forecasting method effective when dealing with a constantly changing world.

Certain Trend- A trend where the future change is known and continuous.

Uncertain Trend- A trend where the future change is unpredictable.

Reader’s Guide

As a stakeholder of the educational industry, i.e. a teacher, principal, student, politician or company representative, some parts of this extensive academic thesis could be disregarded. To get a deeper understanding of Machine Learning’s future role in the public primary school in Gothenburg within a five-year period, enter section 5.2 to read about the four predicted scenarios for 2024, followed by the researchers’ conclusions in chapter 6. If you are eager to develop a broader understanding of the included stakeholders’ interpretations of Machine Learning, skimming the empirical data in chapter 4 might be of interest. However, if you are interested in developing a more profound understanding of the Scenario Planning methodology applied in this research, we recommend you to read section 2.5 in the methodology chapter, as well as section 3.3 in the theoretical framework.

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1. Introduction

The introductory chapter serves to present background information regarding the fields of Machine Learning (ML) and education. As a point of departure, the role of technology will be discussed, followed by a problem discussion of using ML-based tools in education. Thereafter, the purpose of the study and its research questions will be outlined. Lastly, the contribution, delimitations and the outline of the research are presented.

1.1 Background

Technology plays a key role in our daily lives and enables a continuous development of new radical innovations (Tidd & Bessant, 2013). Further, the transformation of technology is a crucial process which has an essential impact on the globalization of activities, economic growth and development (Dicken, 2007). However, despite technology being described as having the power to disrupt industries and change the ways businesses generate value (Tidd & Bessant, 2013), the effects of technological innovation both depends on the inventors and its users. Therefore, some players lack the ability to adapt to disruptive processes (Rosenberg, 2004).

One of the latest fields considered having the ability to unleash the next wave of digital disruption is Artificial Intelligence (hereby referred to as AI) (Bughin, Hazan, Ramaswamy, Chui, Allas, Dahlström, Henke & Trench, 2017). AI is the art of creating machines with the ability to reconstruct thinking, make decisions, solve problems, learn and act in ways normally associated with humans (Russell, Norvig & Davis, 2016). Further, a recent study argues that AI has the possibility to disrupt the relationship between people and technology in the near future (Daugherty & Wilson, 2018). Within the field of AI, numerous sub-groups exist, one of the more successful being Machine Learning (hereby referred to as ML) (Dunjko & Briegel, 2018). ML studies algorithms and statistical models to complete assignments without utilizing explicit instructions. Further, ML uses the studied information to learn and forecast data without the need of being pre-programmed to perform the specific undertaking (Angarita, 2016).

One of the industries where AI in general and ML in particular recently experienced an upturn is within education (Marr, 2018). The industry of educational technology (hereby referred to as EdTech) is one of the fastest growing industries in the world (EdtechXEurope, 2016) and when regarding Sweden, the usage of digital tools is considered having the ability to improve the educational sector (Drafit, n.d.). ML has the capacity to disrupt the future of education and change the current way of teaching, improve student engagement and enable adaptive learning e.g. by customizing lectures (McGuinness, 2018). Further, the technology can help assist teachers with administrative tasks (Holon IQ, n.d). However, despite potential benefits of incorporating ML in the educational sector, debaters question the usage of digital tools within education, relying on research stressing an improved learning by more traditional methods (Jaara Åstrand & Möllstam, 2018). In parallel, introducing untested new technology in school is criticized and highlighted as having a potential negative impact on the future educational results (Skogstad, 2019) However, Marr (2018) argues that ML does not have to replace the teacher and the analogue tools of today. Instead, a collaboration between teachers and ML-based tools should be encouraged (Marr, 2018). Despite differing viewpoints regarding the future of the educational system, ML has the ability to improve parts of the Swedish educational system, wherefore it is an area considered important to research. Further, the Swedish educational industry is currently facing several challenges which will be discussed in the section bellow.

1.2 Problem Discussion

The Swedish educational sector is facing several fundamental challenges. Some of the biggest challenges are related to the scarcity of teachers and the shortage of time each teacher has with the students (Swedish National Agency for Education, 2017b). This problem argues for an increasing need for less administrative tasks, enabling the teachers to focus more on the students. Further, solving the aforementioned problems would correlate with improved academic results (ibid.). As demonstrated by the latest PISA assessments, the Swedish educational results have gradually deteriorated, showing a decrease in all measured subjects and results below the OECD average (Näslund, 2013) except for a demonstrated upturn in 2015 (Swedish National Agency for Education, 2016). Therefore, the Swedish school system is in need for improvements. However, the Swedish school system has great possibilities for innovation and digitalization, which might solve the aforementioned problems currently related to the educational sector (ibid.).

According to the Swedish Association of Local Authorities and Regions (2018), the question is no longer why the Swedish schools need digitalization, but how these tools should be used and to what extent, independent of the inherent inertia in the educational industry. As part of these tools, the technology of ML has the capacity to disrupt the future of education by enhancing student engagement and providing a differentiated and customized way of teaching (McGuinness, 2018; Drafit, n.d; Desmarais & Baker, 2012). Alongside, Google's CEO even argues AI and ML to be more important for the future of humanity than the historical importance of electricity and fire, highlighting the educational sector to be suitable for its usage (Petroff, 2018). However, Bughin et al. (2017) state that ML has not yet reached its full commercial deployment despite its great potential. In addition, contradicting the positive viewpoints, several tech-executives argue that technology is harmful for children, choosing to place them in tech-free Waldorf schools (Weller, 2018).

With these viewpoints in mind, technology might change the field of education, but does not necessarily have to result in improved learning (Jones, 2018). Improved research and knowledge regarding digitalization and when it is preferable to use digital versus analogue tools will be crucial to increase a future adoption rate (EdTech Sweden, n.d; Woolf, Lane, Chaudhri & Kolodner, 2013). Further, due to a continuous disruptive period of technological development, Rexford and Kirkland (2018) argue that educational institutions have difficulties adapting to the rapid changes.

To address the aforementioned educational challenges, the researchers will elaborate around potential scenarios of the future role of ML in the Swedish primary educational sector in Gothenburg. Perspectives from teachers, students, companies, experts and politicians within the fields of ML and public primary education will be included when developing the scenarios. More in detail, the study will specialize in the future role of ML and trends and uncertainties related to its usage.

1.3 Purpose

The purpose of the research is to study the role of ML within the field of the public primary school in Gothenburg in the coming five years by using a Scenario Planning method. Therefore, the purpose includes generating feasible scenarios in line with the chosen research questions. Furthermore, the aim is to generate theoretical contributions to the constantly developing usage of ML and the field of education. In doing so, the study will serve to give insight in how a future adoption of ML in the field of education might look like. In addition, by studying and combining these areas, stakeholders might get a deeper understanding of existing trends and uncertainties related to the ML technology and the field of education and adapt their decision-making accordingly.

1.4 Research Question

Based on the purpose of this study, the following research question has been developed. Further, to answer the question, two sub-questions have been assigned to the study. These questions are to be answered with the method of Scenario Planning.

RQ: What is the role of Machine Learning in the future of the public primary school in Gothenburg within a five-year period?

- *What trends are identified to impact the future role of Machine Learning in the public primary school in Gothenburg?*

- *What uncertainties are identified to impact the future role of Machine Learning in the public primary school in Gothenburg?*

1.5 Contribution

The researchers strive to deliver a theoretical contribution about the feasibility of a widespread usage of ML within the field of education. By interviewing different stakeholders, the researchers aim to provide a broad image of the potential future usage of ML in the public primary school in Gothenburg. The scope is employed to provide new perspectives to the stakeholders in the industry regarding the trends and uncertainties related to the future role of ML. Further, the researchers believe that the study will inspire individuals and organizations to play a more active role in shaping an improved educational future. Lastly, this study will decrease the current gap in theory related to the role of ML within the field of education.

1.6 Delimitations

This study has been limited to the field of education due to its narrow implementation of technology and recent debates regarding educational digitalization and decreasing results. As previously mentioned, the Swedish school is facing several challenges and as ML is said to have the capacity to disrupt the future of education, the technology has been chosen as a main focus of the thesis.

In addition, this study has focused solely on the public primary school in Gothenburg. The public primary school was chosen due to an identified growth of EdTech related companies targeting this section of students. In addition, the main focus of the thesis has been to research public primary schools, as the majority of schools in Sweden are public. Further, due to the Swedish school regulations being dependent upon country, county and municipality, the Gothenburg area, with its new centralized Board of Primary Education, was chosen as the main geographical focus of the study. Furthermore, the timeframe of the study has been limited to a five-year period as Schwenker & Wulf (2013) describe it to enable a development of feasible scenarios when employing the method of Scenario Planning. Lastly, the number of respondents was also limited due to time and availability.

Further, the research has focused solely on stakeholders who either supply products or services for the public primary schools, researching within the field, have a clear insight in the decision-making process impacting the public primary schools in the area of Gothenburg or individuals working/studying in one of these schools. Further, this research does not aim to deliver a detailed description of the technical parts of AI and ML as it will not help the researchers answer the developed research questions.

1.7 Research Outline

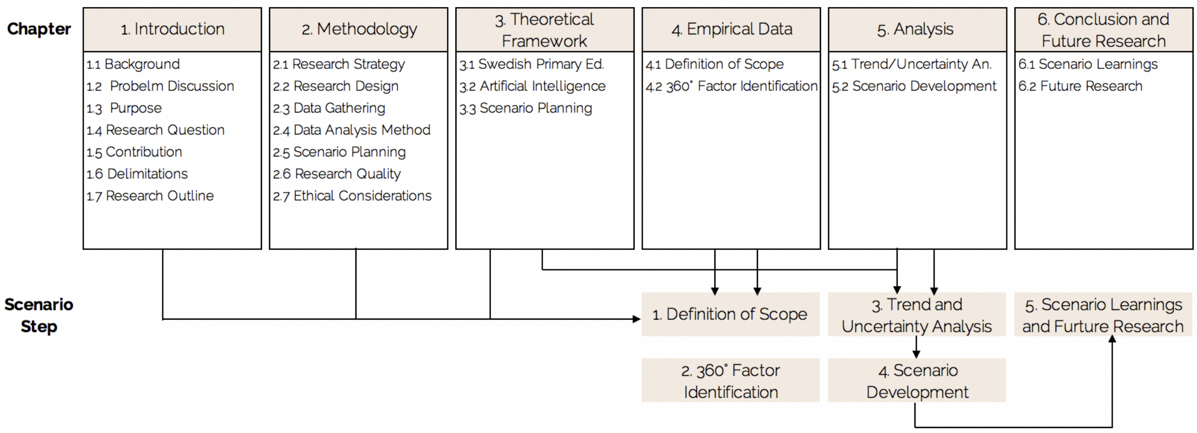

Figure 1.1 Research Outline of the Study

2. Methodology

The following chapter serves to describe how the study has been performed and outlined. The chapter commences by presenting the research strategy. Thereafter, the research design, data gathering, and data analysis methods are presented, explained and motivated. Further, the chapter describes the Scenario Planning method as it will facilitate the answering of the research question by predicting scenarios of the future role of ML. Lastly, quality and ethical considerations will be discussed.

2.1 Research Strategy

Considering the research question and the choice to examine the future, a Scenario Planning method has been applied to the research. Scenario Planning, which is elucidated further in section 2.2 and 2.5, is considered suitable for qualitative studies with quantitative elements (Schoemaker, 1995), wherefore a mixed methods research has been employed. Moreover, Johnson, Onwuegbuzie and Turner (2007) argue that the use of mixed methods can reinforce the researcher's belief that results are valid and not just a methodological occurrence. The mixed methods have been employed by using Grounded theory, where quantitative research filled in the gaps of the qualitative elements in the study. This parallels with Bryman and Bell (2015), stating that it is important to combine the two strategies and not just use them in tandem wherefore all primary data from the data gathering is interrelated to one another.

The qualitative parts aim to explain the results in words rather than numbers as opposed to the quantitative approach. Further, conducting qualitative interviews, which is considered being a common research method applied in qualitative research (Bryman & Bell, 2015), has been the main tool employed in the research. The interviews emphasize the relationship between an aforesaid theoretical framework and its correlation with the conducted research (ibid.) wherefore the research has taken a theoretical framework into consideration when constructing the interview guides. A qualitative approach is considered beneficial when the subject studied is under continuous change and development (ibid.), as the field of ML within education. However, to be able to employ the method of Scenario Planning and to strengthen the results of the qualitative interviews, quantitative elements in terms of a self-completion web survey have been included. With the results from the semi-structured interviews, the researchers constructed a self-completion web survey with questions based on the outcomes from the qualitative research. The empirical data from the survey was firstly quantitatively analyzed, and was further analyzed together with the qualitative data, a mixed analysis, resulting in a scenario development. Figure 2.1 shows the disposition of the methodology of the research.

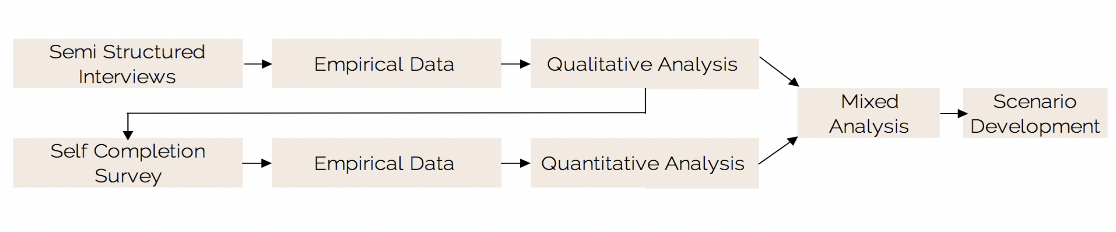

Figure 2.1 Methodology Outline

The research has taken an abductive approach. According to Bryman and Bell (2015), abductiveness is used to draw logical conclusions and build theories of the researched subject. Therefore, the researchers argue that the existing gaps in theory made an abductive approach more suitable. In addition, an abductive approach has allowed an iterative process, changing and adding theory in a non- chronological order (McLaughlin, 2007). In addition, this method has been beneficial due to the usage of a mixed method where the quantitative elements have been employed to fill in the gaps from the qualitative parts. Simultaneously, the abductive approach is both theory testing and theory generating (ibid.), wherefore it has enabled the researchers to develop theory based on theoretical representation.

2.2 Research Design

According to Bryman and Bell (2015), a research design should function as a guide for the collection and analysis of data. As traditional research designs have difficulties with considering future change (Schwenker and Wulf, 2013), a Scenario Planning method has been applied to enable the researchers to study the future role of ML within the field of the public primary education in Gothenburg. The methodology of Scenario Planning, which will be elucidated further in section 2.5, is a suitable framework when investigating areas connected to high uncertainty and constantly changing industries. Due to aforementioned reasons, this method is considered compatible with the constantly developing field of ML. By applying this methodology, future scenarios have been developed by analyzing industrial trends through a collection of both primary and secondary data. The study has been based upon a customized model inspired by frameworks developed by Schwenker and Wulf (2013) and Schoemaker (1995). An overview of the customized model can be found under section 3.3.2. Moreover, the research contained several longitudinal elements, incorporating data gathered from multiple sources by conducting both interviews and a survey. Moreover, the process has been characterized by an iterative nature and a grounded theory approach. A more thorough description of the data gathering in general and the included respondents in particular will be presented below.

2.3 Data Gathering

To provide data of various origin and increase the validity of the study, both primary and secondary data of qualitative and quantitative nature has been gathered. Further, the data collected has been used to conduct scenarios regarding the future role of ML in the public primary school in Gothenburg. The collection of data is based upon an iterative approach. Therefore, both primary data combined with secondary data from the theoretical framework based on a systematic literature review has been utilized. The combination of data and theory has broadened the perspectives and increased the credibility of the study by augmenting its trustworthiness. According to Jacobsen, Sandin and Hellström (2002), this is idealistic since different types of sources can complement and control each other.

2.3.1 Primary Data Collection

Two different methods have been employed to gather the primary data, namely semi-structured interviews and a self-completion web survey. These methods are interrelated and have both been part of the Scenario Planning method. The shaping of the two methods of data collection will be described in the following sections.

2.3.1.1 Semi-structured interviews

Parts of the primary data were collected through interviews as it is considered being a suitable method for qualitative exploratory studies (Bryman & Bell, 2015). The interviews had a semi-structured approach and mainly consisted of open questions, enabling the respondents to answer freely and convey unpredicted insights. Due to the time constraints of the study, the semi-structured interviews enabled the researchers to collect useful and rigid information based on a relatively scarce number of respondents. Further, this type of primary data collection was considered relevant as it enabled the respondents to present their personal insights, appropriate to construct future scenarios.

Sampling

To increase the external validity of the study (Bryman & Bell, 2015), the respondents included in the research were designated with care. Due to the aim of creating future scenarios of ML's role within the educational industry, the purpose of the interviews was to acquire data from a broad spectrum of respondents. The groups considered relevant were 1) Education, 2) Expertise, and

3) Politics, chosen as they all were considered to contribute with different perspectives of ML and the field of primary education. The first group, Education, included two principals, one teacher, two students and a program coordinator for the Teacher's program. Here, all respondents had a direct connection to the public primary school in Gothenburg and were considered to provide information about the usage and demand of digital tools and ML. The principals were considered having a broad understanding of the current demand, usage and decision-making process connected to digital implementation while the teachers were interviewed due to their knowledge of the classroom situation. The students were considered possessing similar knowledge, albeit from a different perspective. The program coordinator however, was interviewed to acquire an overview of the current status of the teachers' program and to provide information regarding the demand and knowledge related to new teachers. Further, the second group, Expertise, included companies and individuals working within the field of education and/or with ML by for example teaching the subject, researching and writing articles or working at a company providing products or services within the fields. These respondents were included to contribute with an overview of existing research as well as industry specific information regarding supply, technology and the implementation of digital tools. The third group, Politics, included local politicians to make the researchers gain knowledge of how political decision-making influences the role of ML in the public primary school in Gothenburg.

All respondents were mainly identified as a result of searching the internet as well as receiving personal recommendations. Using a sampling method where the researchers choose to include respondents of their choice is referred to as convenience sampling (Bryman & Bell, 2015). This type of method often restricts the possibilities of making generalizations of the findings. However, convenience sampling is still considered useful as it enables the gathering of valuable and relevant data and derives conclusions from personal experiences (ibid.). To identify appropriate respondents within the aforementioned respondent groups, several criteria were developed (see Table 2.1*)*. Firstly, since the research has been delimited to Sweden, all respondents included in the study were active in Sweden. Secondly, respondents working within the field of AI/ML connected to the field of education were considered relevant. Thirdly, all respondents included also had a clear connection to the field of education to ensure relevance of the collected data. The common characteristics of the included respondents, argues for a slight level of homogeneity. However, a certain heterogeneity has been strived for by including respondents with different types of knowledge, age, gender and background.

	Expertise	Education	Politics
Purpose	Contribute with an overview of existing research as well as industry specific information regarding supply, technology, and the implementation of digitalization	Provide valuable information about the usage and demand of digitalization in general and ML in particular	Provide insights regarding how political decision-making influences the implementation of ML in the Swedish primary school
Competence	ML and EdTech know-how	Usage and education system know-how	Regulations know-how
Experience	>2 years	Students: Currently involved in the public primary school in Gothenburg Authorities: >5 years	>3 years
Example of Title	EdTech Professor, Educational Materials Developer, Member of the Board Swedish EdTech, Lecturer in Artificial Intelligence	Student, Teacher, Principal, Program Coordinator	Municipal Commissioner, Head of Digitalization and Innovation

Table 2.1 Respondent Criteria

In total, 15 respondents were interviewed from the three different sub-groups (see Table 2.2). More in detail, seven people from the group Expertise, six from the group Education and two from the group Politics were interviewed. The choice to include a considerably larger sample in the two former groups compared to the latter was due to the respondents in the group Politics mainly being interviewed to provide an overview of current regulations and decision-making processes, processes being similar independent of the number of respondents. Regarding the size of the sample, Bryman and Bell (2015) argue that it depends upon the intended research. However, the time and cost constraints of this study were taken into consideration when selecting an adequate sample, in parallel with Bryman and Bell (2015). Further, people considered meeting the developed criteria were interviewed until saturation was reached, i.e. when the respondents provided similar answers.

Respondent Overview					
Respondent	**Sub Group**	**Company**	**Position**	**Date**	**Approach**
Italo Masiello	Expertise	Linneaus University	EdTech Professor	20th of March	Face to face
Anonymous	Expertise	Anonymous	Marketing Manager	21st of March	Telephone
Johan Lundin	Expertise	University of Gothenburg	Professor in Informatics and Education	25th of March	Face to face
Bo Kristofferssson	Expertise	Lexplore, Swedish EdTech	Head of Nordic Markets, member of the board in Swedish EdTech	27th of March	Telephone
Jesper Sörenssson	Expertise	NE	Educational Materials Developer Mathematics and Science	2nd of April	Telephone
Fredrik Heintz	Expertise	Linköping University	Senior Lecturer Artificial Intelligence and Integrated Computer Systems (AIICS)	4th of April	Face to face
Niclas Melin	Expertise	EdTech South East Sweden, NetPort Science Park	Head of Cluster, Digital Cultivator	7th of April	Telephone
Student Grade 9	Education	Student	Student	21st of March	Face to face
Student Grade 3	Education	Student	Student	28th of March	Face to face
Ingrid Lindblad	Education	Fjällskolan	Principal	21st of March	Face to face
Olof Stigert	Education	Gamlestadsskolan	Principal	4th of April	Face to face
Elisabeth Hammarqvist	Educaiton	Dalaskolan	Teacher	8th of April	Face to face
Marie Fredriksson	Education	University of Gothenburg	Program Coordinator, Primary Teacher Education	8th of April	Face to face
Per Wikström	Politics	The Board of Primary Education, City of Gothenburg	Head of Digitalization and Innovation	25th of March	Face to face
Jenny Broman	Politics	Vänsterpartiet (The Left Party), The Board of Primary Education	Municipal Commissioner	1st of April	Face to face

Table 2.2 Respondent Overview

Pilot interview

Before initiating the collection of the qualitative primary data, a semi-structured pilot interview was conducted to enhance the quality of the future interviews, avoid potential bias and identify possible shortcomings related to the questions. The interview was held with Viktor Brodin, a student studying his Master of Science in Marketing and Consumption at the University of Gothenburg School of Business, Economics and Law, as he was believed to provide objective feedback regarding subjects, questions, language and concepts due to a lack of prior knowledge of the subject and study. Thereafter, the respondent provided feedback to the researchers regarding the wording of questions and adjustments were made to ensure that the questions were neutral and not leading. The interview was recorded to enable the researchers to go through the data repeatedly. However, the interview was not transcribed as the information gathered was not intended or considered relevant to be included in the research.

Interview guides

The semi-structured interviews were based on three predetermined interview guides (see Appendix 1), as this research includes respondents from three different sub-groups, differing in knowledge and perspectives. However, all interview guides followed the same structure and were based on similar themes to facilitate the data analysis. The themes included in the guides were developed from the performed literature review regarding ML and its usage within the field of education. The included questions were of open character, enabling the respondents to answer freely and to convey unpredicted insights. Open character questions were considered advantageous for the study as the researchers have been examining a where they lack in expertise. Further, the interview guides enabled the researchers to ask follow-up questions based on the respondents' answers. Lastly, all interview guides ended with a question enabling an adding of additional information.

Practicalities

During the data collection, 11 out of 15 interviews were performed face to face, which was preferred as it is said to enable a more open discussion (Bryman & Bell, 2015). However, due to large geographical distances and the scope of the study, four of the interviews were conducted over telephone. Further, as interviewing is considered being a highly time-consuming method (ibid.), all interviews were limited to the time frame of one hour. The respondents were all contacted by email and given the option to choose time and place of the interview. Further, the respondents were all informed about the purpose of the research. Moreover, since the sample included two underaged primary school students, wherefore their parents were contacted and informed. Thereafter, the parents all confirmed their children's participation. However, due to security reasons, the researchers decided to keep both underaged students' names confidential, referring to them as Student Grade 9 and Student Grade 3 in the thesis. In addition, the predetermined interview guide was not sent out in beforehand to prevent generic and prepared answers (Bryman & Bell, 2015). During the interviews, both researchers were constantly present. However, one of the researchers focused on the process of taking notes while the other asked questions. This enabled the researchers to identify interesting themes relevant for the data analysis without impacting the quality of the held interviews. In consent with the respondents, all interviews were recorded to enable the researchers to go through the data repeatedly and to avoid memory-related mistakes such as losing information (Bryman & Bell, 2015). Furthermore, all interviews were transcribed as it enables a more detailed analysis of the collected data (ibid.). As all respondents spoke Swedish fluently, all interviews were conducted in Swedish to enable the respondents to express themselves more freely.

2.3.1.2 Survey

The main purpose of including a self-completion web survey was to strengthen the results and fill in the gaps from the qualitative interviews. Further, the survey was developed to optimize the usage of the Scenario Planning method and to enable an objective analysis of the empirical data gathered from the semi-structured interviews. Bryman and Bell (2015) describe questionnaires as an effective and cost-efficient way to collect data, enabling an easy way of comparing responses (Bryman & Bell, 2011). The survey was set up as a self-completion web survey, meaning that the respondents responded to the questionnaire via a website (Bryman & Bell, 2011). The survey was created in Webropol due to the researchers' previous experience of using the tool and contained two questions written in Swedish as the respondents all spoke Swedish fluently. The two questions asked the respondents to rank the perceived impact and uncertainty of 11 trends previously identified in the qualitative interviews, on a 1-10 Likert scale related to the future role of ML within the public primary school in Gothenburg, considering a five-year time frame. All trends included in the survey were based on the results from the previously conducted interviews. The survey was published April 16th 2019, 2.13 PM and sent to all 15 respondents who participated in the previously conducted qualitative interviews. The survey was sent out by email and was accompanied with a text describing the survey and its two questions together with its background and purpose. The survey can be found in Swedish in Appendix 2.

Analysis of survey

Due to time and resource restrictions, the survey was closed April 23rd 2019 12.05 PM. 9 out of 15 respondents participated in the survey, resulting in a response rate of 60%. The average response time was 4.11 minutes and the data were transferred to SPSS for further analysis of the variables. Having collected the answers, the average of each trend in the questions was calculated in Excel. The values were further used as a basis for the Perception Analysis (see section 5.1.2, Table 5.2 and Table 5.3). Further, to construct the Scenario Development Matrix, the correlations between the three identified uncertainties were investigated. Pearson's r was used as the evaluation method to investigate the relationship between the variables. According to Pearson's r, the correlation lies between -1 and 1, where a value close to 1 shows a strong positive relationship as opposed to a value close to 0, showing a weak relationship (Bryman & Bell, 2015). The values for the calculated correlation can be found in Appendix 3. Moreover, to check for internal reliability, a Cronbach's Alpha analysis was performed to secure coherence of the respondents' answers. According to Bryman and Bell (2015), perfect internal reliability equals 1, while no internal reliability is indicated by 0. The rule of thumb however, is that ≥ 0.7 is denoted a sufficient level of internal reliability (Bryman & Bell, 2015). The values for the Cronbach Alpha for the three uncertainties can be found in Appendix 4.

Limitations Of Survey

Bryman and Bell (2015) argue for potential errors in a survey research, namely: sampling error, sampling-related error, data collection error and data processing error. Since the survey sample was derived from the same sample as the qualitative interviews, one can argue for it being a convenience sample. However, since the aim of the survey was to triangulate the result and not to get new insights, the researchers argue for a limited sampling error. In addition, one can consider the non-responses to be a limitation since only 60% of the initial qualitative sample answered the survey. Despite a majority of answers, one can argue that the result would have been more accurate with a higher response rate. In addition, the risk of using poor wording in the self-completion questionnaire can open up for misunderstandings (Bryman & Bell, 2015). To prevent this, the researchers sent the survey with instructions of its setup and purpose to the respondents. Further, it was constructed in Swedish to make it more comprehensible, not least for the underaged respondents. Moreover, a short explanation of each trend was provided if considered needed. However, the constant possibility for own interpretations have to be taken into consideration, as well as the imminent risk of potential error in the coding of the data (ibid.). Additionally, the survey used a 1-10 Likert scale instead of a scale from 0-10, since the researchers identified 0 to be redundant as the trends included were previously identified as having an impact on the future implementation of ML. However, this can affect the results in the survey according to Bryman and Bell (2015) since the respondents' answers might be biased due to the absence of 0 as a possible answer.

2.3.2 Secondary Data Collection

In addition to primary data, secondary data was collected from previously performed research regarding both ML and the field of education by a systematic literature review. Bryman and Bell (2015) highlight that a systematic literature review enables an organized way of gathering information and stress that there are several different approaches to perform a systematic literature review (Bryman & Bell, 2015). In this study, secondary data was primarily collected to provide supplementary information about the areas of research and to facilitate the analysis of the primary data. The gathering of secondary data was mainly performed prior to the collection of primary data to enable the researchers to develop a broad base of relevant knowledge before conducting the interview guides. However, due to the iterative process of the research, secondary data was also added continuously during the process. The collection of secondary data was initiated by an extensive search for information on various electronic databases such as Google Scholar, EBSCO and Gothenburg University Library (GUNDA).

Considering the fact that the studied subject is relatively newly developed, the aim of the systematic literature review was to get an overview of the subject and find relevant theory. In addition, the literature covering the Scenario Planning method was used as an umbrella for the entire research. To facilitate the systematic literature review, to ensure a high-quality study and enable a consistency throughout the research, both inclusion and exclusion criteria were developed and assigned to the study (see Table 2.3).

Inclusion Criteria	1) Academic articles relevant for the subject of ML and digitalization in education 2) Consultancy reports written by prominent consultancy firms e.g. The Big Four, McKinsey, Accenture, BCG and Capgemini Invent 3) Regulatory documents regarding the Swedish national school system (e.g. from the Swedish National Agency for Education) 4) Regulatory documents from the City of Gothenburg regarding the school system Research written in Swedish or English 5) Consultancy reports form no later than 2014
Exclusion Criteria	1) Academic articles and reports where the initial purpose of the content affects the data presented in the report (i.e. the data becomes biased) 2) Reports with an possible underlying marketing and/or sales agenda 3) Reports and/or academic articles focusing on technical aspects with ML 4) Reports and/or academic articles focusing on other parts of AI except for ML 5) Research written in other languages than Swedish or English 6) Consultancy reports form later than 2014

Table 2.3 Inclusion and Exclusion Criteria

2.4 Data Analysis Method

The Grounded theory was employed to find an analytical path through the great amount of data forming the foundation of the scenario development. The theory is iterative, stressing a continuous comparison with the initial theory (Bryman & Bell, 2015). The main elements of the Grounded theory are theoretical sampling, coding, theoretical saturation and constant comparison. Theoretical sampling includes collecting, coding and analyzing the data, jointly comparing it to the theory (ibid.) and was in this study performed by collecting primary data and continuously comparing it with theory. According to Saunders, Lewis and Thornhill (2009), analyzing the data continuously enables a more flexible analysis. In addition, the coding step includes breaking down the gathered data into several components (Bryman & Bell, 2015). Prior to the coding of the qualitative analysis, the researchers transcribed the interviews, in line with Bryman and Bell (2015), stating that it allows for a more accurate evaluation of the data. As the data was successfully collected common themes were identified, denominated as factors. The first step of the coding process was of open nature, were the transcribed interviews were read and meaningful patterns were highlighted. Further, the identified factors were sorted into tables based on the three respondent sub-groups. Thereafter, axial coding was executed by categorizing the concepts and turning factors into trends based on predetermined criteria (see Figure 3.5). However, after the qualitative data analysis the researchers requested quantitative data to fulfill the analysis, why a self-completion questionnaire was developed to strengthen the results. The survey was sent to the respondents for them to rank the trends in regards of their impact and uncertainties respectively, arguing for decontextualization and transparent result. Moreover, theoretical saturation refers to the collection of data until a specific category saturates. The researchers reached saturation during the interviews when certain themes were frequently mentioned, and no new information was added. Further, the researchers were offered more respondents to participate but declined due to the achieved saturation. Constant comparison, refers to an iterative process, where the researchers conducted a survey to fill in the research gaps from the interviews and constantly compared it with secondary data. A summary of the Grounded theory process of this study can be found below in Figure 2.2.

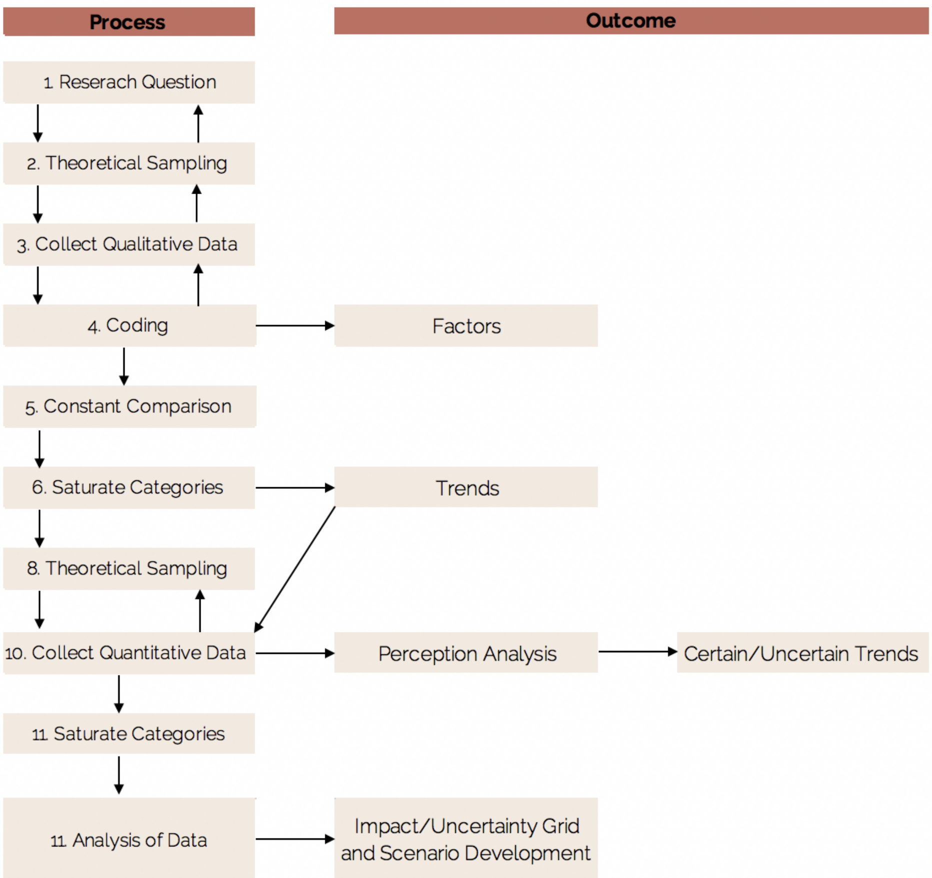

Figure 2.2 Customized Grounded Theory Model- Inspired by Bryman and Bell (2015)

2.5 Scenario Planning

The main method used in the thesis was Scenario Planning, where a customized model, based on theory by Schwenker and Wulf (2013) and Schoemaker (1995), was adopted. The method was used as it is an appropriate model when outcomes are to be determined by the uncertain world of today, taking macroeconomic volatility effects into consideration (Schwenker & Wulf, 2013). The customized Scenario Planning model (see Figure 2.3), which is described more in detail in section 3.3, was conducted in five steps, all including several sub-steps.

In the first step, the definition of scope was identified, based on the Framing Checklist. As part of the Framing Checklist, the definition of scope was constituted by the research question and the overall criteria for the research, including a regional limitation to the Gothenburg area, a five-year timeframe and 15 respondents from three different respondent sub-groups. In the second step, qualitative interviews were performed, and the empirical findings derived from the interviews were put together into factors. These factors were further sorted into tables, to visualize the respondents' answers. In the third step, the researchers analyzed the identified factors to determine certain and uncertain trends. Trend criteria were developed (see Figure 3.5), resulting in 11 trends. To receive an objective result of which trends that could be defined as certain and uncertain, a questionnaire was sent to the 15 respondents. The survey resulted in a 60% response rate, were the respondents were supposed to rank the trends' future impact and uncertainty on a Likert scale between 1-10. The results were later compiled, and an average of each trend was calculated, enabling the researchers to plot the values in an Impact and Uncertainty Grid. Based on the grid, three Uncertain Trends (TC) and eight Certain Trends (TC) were identified, were the uncertainties were further analyzed through a Correlation Matrix and the internal reliability was measured with Cronbach's Alpha. The correlation between the uncertainties were calculated using Pearson's r in SPSS, since the uncertainties had to correlate to constitute the extreme values in the future scenario development. In this step, extreme values were determined based on a Correlation Matrix (see 3.7) and developed criteria (see Figure 3.8). Based on the extreme values, the scenario development matrix was developed resulting in four potential scenarios all including the Certain Trends (TC) and Uncertain Trends (TU) previously determined. Moreover, to show the relationship and interconnectedness between the trends and uncertainties an Influence Diagram was developed. Lastly, the fifth step was performed to discuss the learning outcomes of each scenario, i.e. the conclusions as well as potential future research.

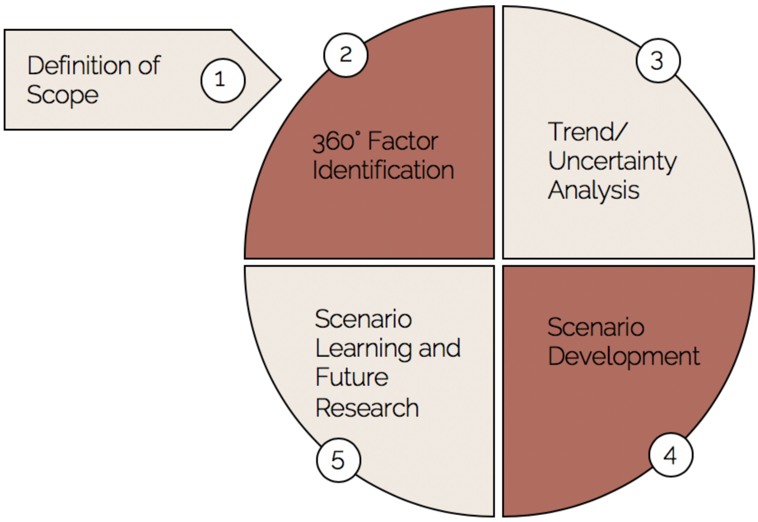

Figure 2.3 Customized Model for Scenario Planning

2.6 Research Quality

When assessing the quality of a qualitative and quantitative study, validity, reliability and replicability are considered being important criteria (Bryman & Bell, 2015). Therefore, to establish the quality of the research, relevant measurements for the criteria will be presented below, including a section discussing bias and subjectivity.

Validity

According to Bryman and Bell (2015), the concept of validity can be divided into internal and external, where internal validity refers to the credibility of the study, justifying that there is a match between the researchers' observations and the theoretical ideas developed. In this study, focus has been put on carrying out the research in parallel with research standards related to e.g. research design. Further, issues related to the validity of the research has been minimized by well-defined research questions with limitations suitable for the scale and scope of the research. External validity is related to generalization and if conclusions can be considered viable in other settings (Bryman & Bell, 2015). Problems that could emerge in relation to external validity is connected to generalization due to a limited number of respondents. Due to the scale and scope of this research, the number of respondents has been limited wherefore a generalization of the results will be done with care. However, to minimize difficulties related to external validity, data was collected until saturation was considered achieved.

To validate the answers from the respondents, the concept of respondent validity has been applied, which has ensured correspondence between theory and the answers from the participants. The researchers have therefore carefully transcribed the interviews. This was considered beneficial to minimize possible misinterpretations and decrease the gap between the theory and primary data. To ensure the validity of the survey, the researchers have investigated whether or not the two included questions asked measured what was intended by a Cronbach's Alpha analysis. According to Bryman and Bell (2015), face validity is crucial for every study, investigating if the question measures the fundamental concept of the study. To ensure face validity, the survey was both tested by the researchers and a pilot respondent, before emailing the survey to the respondents, to ensure the understanding of each question and decrease the risk for misunderstandings.

Reliability

Bryman and Bell (2015) state that the reliability of a research refers to if the results of a study can be repeatable i.e. if similar measurements could be performed in other studies with similar conditions. Reliability can be divided into two groups, namely, internal and external. The external reliability refers to a study's possibility to be replicated (ibid.). As this research has focused on developing future scenarios within ML, a growing and constantly changing technological field, future results might differ as the industry of ML will most likely continue to change. Therefore, an issue related to this study is the risk of it being outdated in the near future. To minimize this risk, this research has been performed so that it can function as a base for future adoption and be relevant for future studies. Further, the research has followed existing standards related to mixed method studies. In particular, transparency has been focused upon by presenting a clear and detailed research methodology.

When regarding the internal reliability, i.e. if all researchers involved in a study interprets the collected data similarly (Bryman & Bell, 2015), the researchers have both participated in all interviews and constantly been reviewing the other researcher's work. In addition, the interviews have been transcribed to minimize room for interpretation. Further it has constantly involved third parties, such as a supervisor and external companies to supervise the process. Thus, the study's internal reliability has increased. In addition, the internal reliability of the quantitative survey has been taken into consideration to measure the consistency of the respondents' answers according to the Likert scale. Therefore, a Cronbach's Alpha analysis has been conducted.

Replicability

According to Bryman and Bell (2015), replicability refers to the possibility of others replicating a study. Despite the fact that qualitative studies are considered difficult to replicate due to their often very specific settings (ibid.), this study will aim to mitigate the possibility of being unreplicable. The transparency, documenting all steps of the methodology, analysis and reflections, will allow readers to evaluate the study and its findings and hence, increase the replicability. Further, the quantitative part of the study is argued to possess high replicability as well, since the survey have been attached in Appendix 2. However, the survey's dependability on the previous research steps argues for a somewhat decreased replicability.

Bias and Subjectivity

Bias and subjectivity has the potential to impact the above-mentioned criteria for quality. Firstly, the research has been conducted by two researchers, which can result in observer error and bias. To minimize this risk, the researchers used an interview guide when conducting all interviews. Further, both researchers observed each other's work during the whole process and were constantly observed and supported by a supervisor and fellow students. Secondly, respondent bias, i.e. errors related to participants biasing their answers due to e.g. their backgrounds or line of work, might impact the outcome of the developed scenarios. To mitigate this risk, the study encompassed different perspectives from three respondent sub-groups, including respondents with different knowledge and backgrounds. In addition, this risk was counteracted as the final scenarios was built upon trends identified from a collective image of the respondents' answers, combined with other types of data.

2.7 Ethical Considerations

It is essential to acknowledge ethical considerations, such as e.g. confidentiality, integrity and anonymity (Bryman & Bell, 2015). In this research, all respondents were informed about the purpose of the study and gave their consent to participate. When regarding the qualitative interviews, the respondents were all offered the opportunity to be anonymous and to refuse to answer questions considered sensible. Amongst the respondents, one preferred to be anonymous, referred to as Anonymous and the two underaged students' names were removed from the research by the authors. Moreover, the respondents were all informed that the recordings were only designated for the purpose of this research. When regarding the quantitative survey, all respondents were informed about its purpose. Further, all survey responses were anonymous.

3. Theoretical Framework

The following chapter will present a systematic literature review. Firstly, the Swedish primary education system will be described. Moreover, the definition and history of AI in general and ML in particular will be elaborated upon. Further, barriers related to the subject as well as how AI and ML are implemented within the field of education are presented. Lastly, literature concerning Scenario Planning will be presented as well as a customized Scenario Planning model.

3.1 Swedish Primary Education System

The School System

The Swedish primary education system is based on a ten-year school with mandatory attendance and is free of charge for all children. In 2018, the preschool class became compulsory, changing the mandatory years from nine to ten (Swedish National Agency for Education, 2018a). Further, to make the school equal, it is a statutory requirement to offer the same school quality all over the country (Swedish National Agency for Education, n.d.) and for children with special needs or intellectual disabilities, there is a special needs comprehensive school. The majority of schools in Sweden are public (Swedish National Agency for Education, n.d.) why the main focus in the thesis is researching public comprehensive schools.

The Swedish Parliament is responsible for the economic framework for the public primary school, including several important steering documents. Firstly, the Education Act consists of the fundamental regulations for the public primary schools. Furthermore, ordinances are issued by the government, e.g. the school curriculums describing the norms, values and learning outcomes for each course. It is the Swedish National Agency's responsibility to ensure a complete and correct education for all children in Sweden (Swedish National Agency for Education n.d.).

The structure of the Swedish school system is complex and consists of policymakers on both a national and regional level. At a national level, the state controls the schools by regulations. In Sweden, the parliament, county council and local authorities all have the possibility to govern the education sector (Ringarp & Nihlfors, 2017). According to Anna Brodin[1], Head of unit at the University of Gothenburg, the general regulations are set on a national level, while the municipalities are in charge of the economic framework regarding the public school. The city councils however, are in charge of the compensatory transfer payment and its size. The

[1] Anna Brodin. Head of Unit at the University of Gothenburg. Email. February 13 2019

compensatory transfer payment refers to the amount of money the school receives for each student attending the school, where each municipality have different models for its amount (Swedish Association of Local Authorities and Regions, 2017). Anna Brodin[2], Head of unit at the University of Gothenburg, further describes that after the allocation of the compensatory transfer payment, the principal of each school is responsible for the budgeting, i.e. the authority to decide what to purchase, e.g. digital tools. Therefore, each principal have the right to decide how to spend the compensatory transfer payment. For the schools to receive additional financial support, each school can apply for donations from e.g. the Swedish National Agency for Education, which is responsible for several efforts to encourage a rethinking of the school system, e.g. improved digitalization. However, these additional donations are often restricted.

When regarding Gothenburg, the authority was moved from the districts in 2018 resulting in decisions now being made on a central level to make the system more equal (Gothenburg City, n.d.). The main goal is further to focus on more vulnerable areas. The compensatory transfer payment is dependent upon several criteria described in the budget of Gothenburg City (2018) namely, gender, immigration, academic background of the caregiver, economic aspects, living situation, the salary of the caregivers, foreign background, Human Development Index (HDI) and the social situation of the neighborhood the student lives in. Therefore, all schools receive a unique amount of payment per student (Gothenburg City, 2018).

Digitalization

In 2022, the national goal for the Swedish school is to be world leading within the field of digital education. This goal constitutes three focus areas namely, to develop digital competence for everyone working in the Swedish school system, to attain equal distribution and usage of the digital tools and lastly to research and follow-up the results and possibilities of the digitalization strategy. However, according to the Swedish Association of Local Authorities and Regions (2018), Sweden has to reform the education system to keep up with the digital revolution. Therefore, the Swedish National Agency for Education carries out several efforts where digitalization is prioritized. In the Education Act from 2018 a new digital strategy enables for example a usage of new digital tools and scheduled lectures in programming (ibid).

According to the Government Offices of Sweden (2017), if the possibilities of digitalization are learnt from an early age, Sweden will have the potential to become world leading. However, to fulfill the goals, the tools need to be evenly distributed between cities, gender, socio-economic

[2] Anna Brodin. Head of Unit at the University of Gothenburg. Email. February 13 2019

background and other demographic variables, highlighting the importance for a national strategy to ensure the same prerequisites for all students (Government Offices of Sweden, 2017). However, the main challenge is to give the right preconditions to the schools, as well as involving actors from the business sector and academia to continuously carry out and test new practices. Therefore, integrating different groups and their expertise and to create a profound understanding of the importance of digitalization amongst teachers, principals, the schools and the responsible purchaser of the digital tools. Further, this might lead to common standards and solutions in the future for the Swedish school system (ibid.).

The Future of Education

In a report by Holon IQ (n.d), potential future scenarios of the Swedish education sector in 2030 are presented, highlighting implications for a future more digitized education. According to Holon IQ (n.d), one of the main uncertainties following the technical revolution is the security aspect, concerned with authentication and verification. That is, even if the technology is mature enough, the regulations in general and the technical infrastructure in particular will play an important future role. However, Holon IQ (n.d) states that deficient investments in technical infrastructure and innovation in the traditional sector hampers the sector and its innovation due to conservative regulatory decisions. Further, Holon IQ (n.d) argues that the classroom and hence the role of the teacher will change in the near future due to technical revolutions and increased demand for products based on technology from for example ML. However, the importance of the teacher and human interaction is still highlighted, arguing for ambiguity. Further, the importance of AI and ML in education compared to other industries will continue to be relatively low and if the industry are to keep up with other industries the focus needs to be different and the teachers of today need to be trained to develop skills preparing for a digital future (ibid.). Nevertheless, Holon IQ (n.d) argues that the administrative tasks rather than the educational will be automated in the near future.

Woolf et al. (2013) state that more research is needed within the field to augment the usage of digital tools within education. More research would lead to a combined usage and knowledge regarding when digital tools are preferable over analogue (ibid.). Moreover, the digitalization of the school system cannot advance in isolation. Instead, it should be considered as one element in a complex system where the pedagogical environment between teachers and students plays a crucial role (ibid.). The gap between the education system and the great potential of digitizing the field of education are further highlighted by EdTech Sweden (2016), describing the EdTech industry to be one of the industries with greatest growth potential. However, the inert digitalization process is a crucial bottleneck stifling the innovation within the field (ibid.). Additionally, EdTech Sweden (2016) argues for a considerably slow digitalization process, despite the increased supply, due to deficient political governance. Moreover, a more long-term perspective is requested considering the fact that the educational industry is complex. Therefore, the level of scalability is low, and the government procurement process has to become clearer along with a clear national digitization strategy addressing the possibilities and difficulties with digitalization, e.g. investments in digital infrastructure and inequalities (ibid.).

3.2 Artificial Intelligence

The technology of AI emerged in the 1950s, in relation to the initial development of electronic digital computing and the so-called Turing test. The main goal with the test was to study if computers could communicate in a human way and is therefore considered as being AIs' point of departure. Moreover, in 1955, the term Artificial Intelligence officially emerged (Bughin et al., 2017). Despite the technological advancements which occurred during the 20th century, the field experienced inertia due to slow progress, leading to a drop of resources in the field of AI (Royal Society, 2017). Since the emergence of the AI technology, the field has experienced many different cycles of hype (Reaktor, n.d.). These cycles have all been initiated by success stories which has excited many different stakeholders, leading to an increased funding and research of AI. However, each cycle has ended with the research and development not being able to attain what was first promised, resulting in decreased interest, research and investments (ibid.). However, since the 21st century, AI has caught continuous attention partly due to developments in fields related to deep learning, supported by larger amounts of data and better computers. The technological advancements influenced investors and researchers and made them believe that a further development of AI could be both practical and profitable (Bughin et al., 2017).

Defining AI

AI is an umbrella term that encompasses various sub-areas focusing on studies in different parts of intelligent behavior. Due to the broadness of the technology and the discussion regarding the significance of 'intelligence' (Bughin et al., 2017), the definition of AI cannot be considered fixed (Royal Society, 2017). However, in broad terms, the technology is commonly described as the art of creating machines with the ability to replicate thinking, make decisions, solve problems, learn and act in ways normally associated with humans (Russell, Norvig & Davis, 2016). Further, AI includes the characteristics of autonomy and adaptivity. Autonomy refers to machines' ability to execute complicated tasks without constantly requiring explicit instructions whereas adaptivity refers to the technology's capacity to learn from previous experience to improve future performance (Reaktor, n.d.).

Due to the large corpus and nebulous perception of AI, the technology is often categorized (Swedish National Agency for Education, 2017a) and human intelligence is often used as a benchmark for the progress of AI as it cannot yet be fully copied by machines (Stone, Brooks, Brynjolfsson, Calo, Etzioni, Hager, Hirschberg, Kalyanakrishnan, Kamar, Kraus, Leyton-Brown, Parkes, Press, Saxenian, Shah, Tambe & Teller, 2016). The Swedish National Agency for Education (2017a) choose to categorize AI into three levels of intelligence, namely: *Artificial Super Intelligence, Artificial General Intelligence* and *Artificial Narrow Intelligence. Artificial Super Intelligence* is a type of AI smarter than the best human experts in one or many areas such as science, social behavior and general knowledge. *Artificial General Intelligence* refers to machines whose intelligence can be used to solve every possible problem similar to a human being. *Artificial Narrow Intelligence* is when the machines' intelligence is intended for one specific task (Swedish National Agency for Education, 2017a). Despite the fact that AI often is categorized into different levels of intelligence, other state the difficulties of comparing the technology's abilities to perform tasks as it says nothing about its ability of solving divergent problems (Reaktor, n.d.).

Machine Learning

ML is one of the more successful sub-groups of AI (Dunjko & Briegel, 2018). Further, it is a technology which allows an achievement of *Artificial Narrow Intelligence* (Royal Society, 2017). The technology is considered being an important technological development which has advanced rapidly during the past years as it has enabled machines to identify valuable information amongst large volumes of data, without having to be specifically programmed for the task (Angarita, 2016). Due to the recent technological progress, ML has the ability to outperform human performance in executing certain tasks, e.g. image recognition. However, human performance continues to be superior in many fields (Ranbotham, Kiron, Gerbert & Reeve, 2017).

ML is a technology studying algorithms and statistical models to learn particular functions without utilizing explicit instructions (Angarita, 2016). Instead, the technology learns directly from examples and experiences from data. Further, ML solves problems by being given a task together with large amounts of data exemplifying how the undertaking can be performed or from which it can identify meaningful patterns. From the data, the technology understands how to accomplish a certain output. Due to ML's ability to learn from a great volume of data, the system is able to perform tasks which traditional programming methods cannot achieve

(Ranbotham et al., 2017). ML can be divided into three sub-groups. Firstly, *Supervised Machine Learning,* a system trained with labelled data identifying how the data is labelled and use this knowledge to predict the groups of other data. Secondly, *Unsupervised Machine Learning* includes a type of learning without the usage of labels that strives to identify features that separates data points from each other. Lastly, *Reinforcement Machine Learnin*g refers to machines learning from past experience, including machines which are able to understand the consequences of its decisions and further use this information (Royal Society, 2017). Currently, ML is applied in many industries where numerous applications are performed by a technique called deep learning which can be used within the various sub-groups of ML and has enabled large advancements within the field of AI (Lecun, Bengio & Hinton, 2015).

Limitations and Implications

The ML technology is related to several limitations, impacting its current abilities (Jordan & Mitchell, 2015). One of the limitations is the technology's reliance on large volumes of data which creation often is both time-consuming and resource intensive (Royal Society, 2017). Further, one crucial difficulty is to develop systems with the human competence of sound practical judgment, which can lead to fundamental errors. In addition, ML experiences difficulties related to understanding the intent of humans, resulting in challenges in situations where machines are assisting humans. An additional implication is algorithmic bias, which includes a discriminating embeddedness, resulting in unfair outcomes linked to e.g. ethnicity and gender (Reaktor, n.d.). This limitation is mainly a result of human bias and often occurs in relation to search engine results. Further, ML has the possibility to manipulate the truth, create fake news and fabricate false evidence.

Barriers of Adoption

A common fear is that technology in general, and ML in particular has the possibility of replacing humans due to a superior performance (Barrat, 2013). However, the critique that human jobs will be replaced by robots has been discussed by Nedelkoska and Quintini (2018) who argue that the pace and magnitude of it is slower than firstly expected. Moreover, the high-skilled jobs involving elements of knowledge and complex social relationships are hard to automate (Nedelkoska & Quintini, 2018). Additionally, the degree of digitization is highly dependent upon the country discussed, where the Nordic countries face a considerably lower risk of becoming automate compared to less developed countries due to more high-skilled labor. Therefore, digitalization in the Swedish educational field should not possess the risk of replace human jobs due to the high level of social relationships and human elements required.

Moreover, the rate of adoption can be constrained by factors such as workers' social preferences for digital tools as well as the unit labor cost (ibid.).

In a report published by Vinnova (2018) one potential barrier of adoption is the difficulty of combining the implementation of AI and the public sector, due to regulations and inertia. Further, the study shows that the knowledge and implementation of AI is at its lowest on a municipal level while simultaneously 80% of the municipalities believe in the future of AI (ibid.). Further, Vinnova (2018) highlights that the lack of competencies embedded in the organizations as well as time and financial constraints, function as problems for implementation. In addition, municipalities are generally not adjusted to fast changes since several requirements and laws are to be taken into consideration. Therefore, the main challenge in implementing AI in Swedish schools is not the technological development. Instead, the main difficulties originate from structural problems (ibid.). According to Vinnova (2018), the municipalities in general and the Swedish school in particular is not organized effectively enough why the organizational need to be prioritized to encourage innovation in the Swedish school system (Vinnova, 2018).

Artificial Intelligence and Machine Learning in Education

The usage of ML in the classroom is currently limited (Woolf et al., 2013). However, despite its limited usage, Swedish schools spent approximately 60 billion in 2016 on EdTech, indicating a growing demand for digitized learning. In parallel, the market shows a continuous growth with an increasing number of startups entering the market, especially within the market segment of teaching materials where the largest future growth is expected in the near future (EdTech Sweden, 2016). Further, the technology of AI is likely to play a large role of the growth expenses on EdTech (Swedish National Agency for Education, 2017a). Available AI tools have the ability to engage and connect students and provide access to a large pool of learning materials (Woolf et al., 2013). Furthermore, AI has the potential to enable several desired educational objectives related to e.g. teaching efficiency and effectiveness, providing education for all, and developing skills considered essential in the 21st century (Swedish National Agency for Education, 2017a).

The technology of AI is currently used primarily in the area of adaptive learning where intelligent programs identify how an individual learn in order to adapt educational content accordingly. Adaptive education personalizes the education by enhancing reflection and analysis, and enabling students to learn in the most suitable way (Swedish National Agency for Education, 2017a; Woolf et al., 2013). In addition, adaptive programs can facilitate the work of the teachers as it can help them identify where each student need to develop and adjust assignments and time accordingly (ibid.). Intelligent Tutoring Systems (ITS) is a technological system used in the area of adaptive learning (Vanlehn, 2011). This type of tutoring has advanced during the last decade and involves computers providing tutoring in an electronic form, enabling the student to solve problems based on their own personal preferences while receiving feedback and instructions (ibid). Personal educational adaption is considered being positive for improved learning. However despite its availability on the market, many tools are considered being underdeveloped, having the ability to negatively impact the success of the students (Liu, McKelroy, Corliss & Carrigan, 2017).

To investigate the future role of ML in the public primary school, the theory of Scenario Planning will be employed. Therefore, theory regarding this method will be presented thoroughly in the next section. However, as existing theories are adapted to an organizational viewpoint, a new customized framework has been developed, suitable for an academic and industrial context. The customized framework is inspired by Schwenker and Wulf (2013) and Schoemaker (1995), why the following sections will described the two models, followed by the researchers' customized framework.

3.3 Scenario Planning

Scenario Planning is a strategic forecasting method effective when dealing with a constantly changing world (Postma & Liebl, 2005). Further, the method is beneficial for both academics and companies when desiring to forecast and control future developments (Lindgren & Banhold, 2003). Scenario Planning is appropriate to enable people to overlook existing settings and to enable users to take advantage of new opportunities (Schoemaker, 1995). Royal Dutch/Shell used scenarios in the 1950s' as a planning tool to enable more precise forecasts (Shell International, 2003) and ever since, different types of Scenario Planning methods have emerged. Traditional planning methods, such as e.g. forecasting, are often used to prognosticate small and short term change (Schoemaker, 1995). However, Scenario Planning is considered superior to make predictions in a highly uncertain world, when the area of study has not been developing as anticipated, when bureaucracy is hindering the area of study from development and when it is likely to occur large changes in the industry (ibid.). When employing Scenario Planning, scenarios are used to outline the future of a specific question (Kosow & Gabner, 2008). A scenario is often described as a story portraying a potential future state (Shell International, 2003). However, despite the method being used to describe the future, the objective is not to create a clear and full image of the chosen area of study, but to map the key elements that will act as drivers towards future developments (ibid).

3.3.1 Established Frameworks

Several theories address the Scenario Planning method, all with similar goals and points of departure, yet with different viewpoints regarding the most appropriate execution. In the following chapter, the researchers have included Scenario Planning literature, building upon the frameworks developed by Schwenker and Wulf (2013) and Schoemaker (1995). The framework developed by Schwenker and Wulf (2013) was mainly included as it is a modern version of the highly influential model by Royal Dutch Shell which has influenced many newly developed approaches (Schwenker & Wulf, 2013). Shoemaker's 10 Steps of Scenario Planning (1995) are built on the same foundation as other Scenario Planning models and was considered relevant as it includes a greater number of steps, adding an additional layer to the framework developed by Schwenker and Wulf (2013). Below follows an introduction of the two models.

Schwenker and Wulf

Schwenker and Wulf (2013) present six steps of Scenario Planning (see Figure 3.1) , building on to the developed framework by Royal Dutch Shell (Shell International, 2003). The six steps will be described more thoroughly in the following sections.

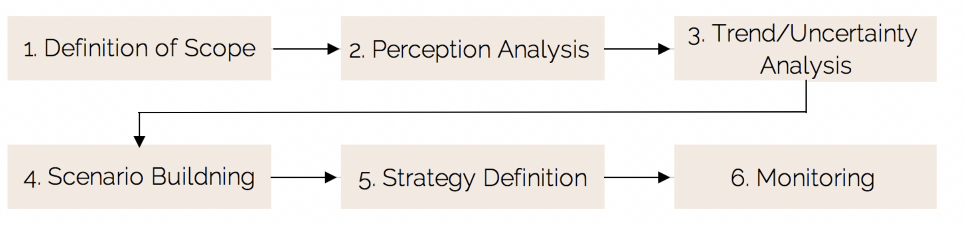

Figure 3.1 Visualization of the Scenario Planning Model by Schwenker and Wulf (2013)

Step 1: Definition of Scope- The goal of step 1 is to define the general scope of the research, which Schwenker and Wulf (2013) suggests the Framing Checklist to be a tool for (see figure 3.4). The Framing Checklist has the overall purpose to answer the research question of the project. Subsequently, Schwenker and Wulf (2013) choose to include additional four sub-groups, namely: the strategic level of analysis, participants of the scenario development process, stakeholders and time horizon. Regarding the strategic level of analysis, scenarios can be developed at different levels, both on global, regional or local level and on corporate or industry level (Schwenker & Wulf, 2013). Regarding the time frame, a time horizon should be set to stretch between three to five years as such a time period enables feasible scenarios. The identification of internal and external stakeholders is further important and the last step includes the identification of participants (Schwenker and Wulf, 2013).

Step 2: Perception Analysis- The purpose of the second step is tied to the stakeholder identification in the Framing Checklist in Step 1 (Schwenker and Wulf, 2013). Step 2 results in a comprehensive list of factors potentially influencing the future of the industry. Further, a developed questionnaire enables the stakeholders to outline the perceived impact and uncertainty of the trends in relation to the industry. After step 2, knowledge of key emerging trends in the industry from different viewpoints should be possessed (ibid.).

Step 3: Trend and Uncertainty Analysis- Step 3 analyzes the factors identified in step 2 to develop two dimensions. These dimensions are further analyzed in a so-called Impact and Uncertainty Grid, which is divided into three different sections, secondary elements, trends and uncertainties (Schwenker & Wulf, 2013). The secondary elements are factors with a minor impact on the study and are therefore excluded. The trends on the other hand, are predicted to have a major impact, and are therefore used in the following steps of the model. The critical uncertainties are also considered having a great impact and, in addition, high uncertainty wherefore they are also further included in the model. Between three and seven critical uncertainties are often identified (ibid.).

Step 4: Scenario Building- Building upon the trends and uncertainties identified in step 3, step 4 strives to develop specific scenarios. Therefore, a Scenario Matrix is used as the primary tool (Schwenker & Wulf, 2013). As a fundament of the Scenario Matrix, two extreme values should be developed. Afterwards, the extreme values and previously identified trends are analyzed in the matrix building upon four different quadrants. Four scenarios are considered as the maximum feasible number of scenarios able to be addressed (ibid.). Dependent on the research conducted, the scenarios are given distinct names, and details are added into the scenarios in two different steps. The first step is called the Influence Diagram and is dependent upon the data found in step 3. The main goal of this part is to identify causes and relationships. The second step is to create a storyline for the four different scenarios, which should build on the data in the Influence Diagram, the main goal is to add further details to the different scenarios (ibid.).

Step 5: Strategy Definition- The goal is to develop certain strategies for the four scenarios identified. The importance of this step is for the company to move from diffuse plans to a concrete plan of action (Schwenker & Wulf, 2013).

Step 6: Monitoring- The last step covers the implementation of the final strategy by monitoring the strategy and adjusting it to potential industrial changes. This aims to identify which of the four strategic options that need to be executed or revised.

Schoemaker's 10 Steps of Scenario Planning

Schoemaker (1995) presents a 10-step model that enables scenario development to mitigate errors related to decision making. The ten steps will be explained further below and are visualized in Figure 3.2.

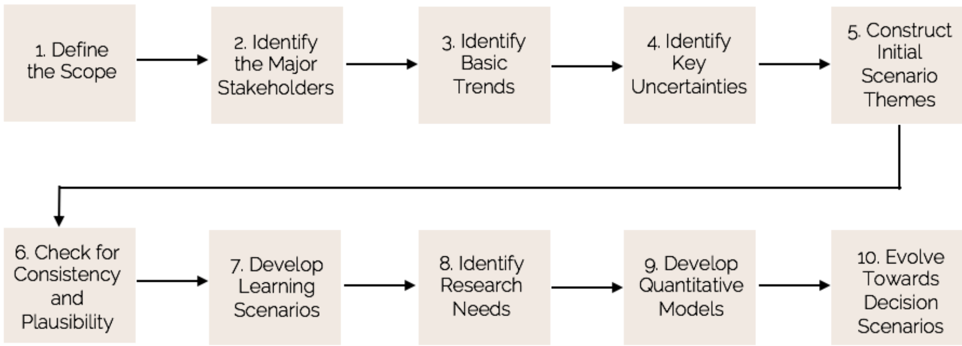

Figure 3.2 Visualization of the Schoemaker (1995) 10 Steps of Scenario Planning

***Step 1: Define the Scope* –** The initial step covers the overall scope and time frame of the analysis. The scope should cover e.g. technologies, geographic areas and markets. The time frame is dependent on product life cycles, competitors, technological change and other potential external factors. Once the scope and time frame is determined, what currently constitutes the greatest value should be assigned to anticipate future change, since uncertainty and concerns are a valid starting point for future Scenario Planning (Schoemaker, 1995).

***Step 2: Identify the Major Stakeholders* –** The second step addresses the stakeholders that will have a future stake in the identified scope in step 1. Important is to address the stakeholders that will be affected of and influenced by possible changes (Schoemaker, 1995).

***Step 3: Identify Basic Trends* –** In this step, trends should be identified. External trends should be briefly explained and further analyzed to explain how it affects the company and/or the industry. A trend is defined as a change that is known and will continue in the same direction. To facilitate the process, one can list the trends as positive, negative or uncertain (Schoemaker, 1995).

***Step 4: Identify Key Uncertainties* –** The most important uncertain events that may affect the company or industry should be considered in order to determine their possible outcomes and the relationship between them (Schoemaker, 1995).

***Step 5: Construct Initial Scenario Themes* –** Trends and uncertainties should be identified, which all together constitute the foundation of the future scenario development. To develop the first scenario, one strategy might be to identify an extreme scenario with all positive outcomes in one scenario and all negative in another (Schoemaker, 1995).

***Step 6: Check for consistency and plausibility* –** Review the trends and their internal consistency. Firstly, by analyzing and removing the trends that do not match the chosen time frame. Secondly, the identified trends and uncertainties should be examined and removed if they are not compatible. Lastly, the concerned stakeholders should be exposed to the identified trends and asked if they desire to change their positions. If so, the scenarios should be changed (Schoemaker, 1995).

***Step 7: Develop Learning Scenarios* –** Review the scenarios to identify themes. Distinguish the themes considered relevant and categorize potential outcomes and trends around them. Name the developed scenarios and use them as a basis for further research rather than for decision making (Schoemaker, 1995).

***Step 8: Identify Research Needs* –** Identify interesting areas in need for future research by reviewing the developed scenarios (Schoemaker, 1995).

***Step 9: Develop Quantitative Models* –** Reexamine the internal consistencies of the scenarios and evaluate the possibility to develop a quantitative model (Schoemaker, 1995).

***Step 10: Evolve Toward Decision Scenarios* –** Employ an iterative process to identify relevant scenarios, analyze strategies and develop new positions (Schoemaker, 1995).

3.3.2 Customized Scenario Planning Model

To apply a consistent approach throughout the thesis, the researchers have chosen to combine the two models previously described into a five stepped customized framework of Scenario Planning. Further, the researchers have identified that the previous developed theories have an organizational viewpoint. However, as the aim of this model is to enable a usage in an academic and industrial context, the researchers have developed a customized Scenario Planning model considered suitable for the context of digitalization within the field of education. A summary of the model is presented below in Table 3.1.

Step	Task	Result	Tools
Step 1: Definition of Scope	Identify the scope of the study	A common ground for the Scenario Planning	Framing Checklist
Step 2: 360° Factor Analysis	Identify factors	An understanding of the respondent's perspectives	Respondent trend tables and qualitative interviews
Step 3: Trend/Uncertainty Analysis	Identify Certain Trendss (TC) and Uncertain Trends (TU) to analyze	An identication of Certain Trends (TC) and Uncertain Trends (TU)and their correlation	Trend identification tables, Impact and Uncertainty Grid, Correlation Matrix, Self-completion Questionnaire
Step 4: Scenario Development	Develop feasible and relevant scenarios	Identify extreme values and construct scenario storylines	Scenario Matrix and Influence Diagrams
Step 5: Scenario Learning and Future Research	Conclude the developed scenarios and suggest future research	Conclusion and future research	No tools

Table 3.1 Summary of the Customized Scenario Planning Model

The model has mainly been influenced by the frameworks of Schwenker and Wulf (2013) and Schoemaker (1995). Various parts of the two frameworks have been aggregated between and within the frameworks. In addition, some parts of the existing frameworks have been disregarded as they do not correspond to the academic nature and industrial context of this research. Therefore, the customized Scenario Planning model consist of five steps, Definition of Scope, 360° Factor identification, Trend and Uncertainty Analysis, Scenario Development and Scenario Learning and Future Research. Figure 3.3 presents an overview of all five steps which will be further elaborated upon in the following sections.

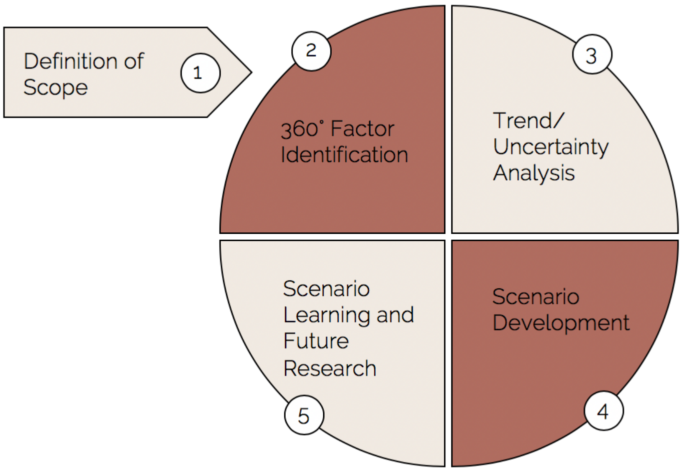

Figure 3.3 Customized Model for Scenario Planning

Step 1: Definition of Scope

The initial step is of importance to enable a common ground regarding the desired outcome of the developed scenarios. This parallels with the models developed by both Schwenker and Wulf (2013) and Schoemaker (1995), highlighting that defining the scope is important for developing scenarios. According to Schwenker and Wulf (2013), this step is essential for the future developed scenarios to be understood by external parties. To define the scope, a Framing Checklist should be developed (see Figure 3.4). Schwenker and Wulf (2013) stress that composing a Framing Checklist enables the developers of the scenarios to frame their analysis. In line with Schwenker and Wulf (2013), the development of a Framing Checklist commences with defining the overall goal of the project. In academic research, the goal should parallel with the research question and purpose of the study. Subsequently, Schwenker and Wulf (2013) choose to include additional four sub-groups in relation to the identified overall goal, namely: the strategic level of analysis, participants of the scenario development process, stakeholders and time horizon. As this model should be applicable in academic research, it will treat stakeholders and participants as one group as the participants consist of the stakeholders in the industry. Regarding the time frame, a time horizon of five years will be employed as suggested by Schwenker and Wulf (2013).

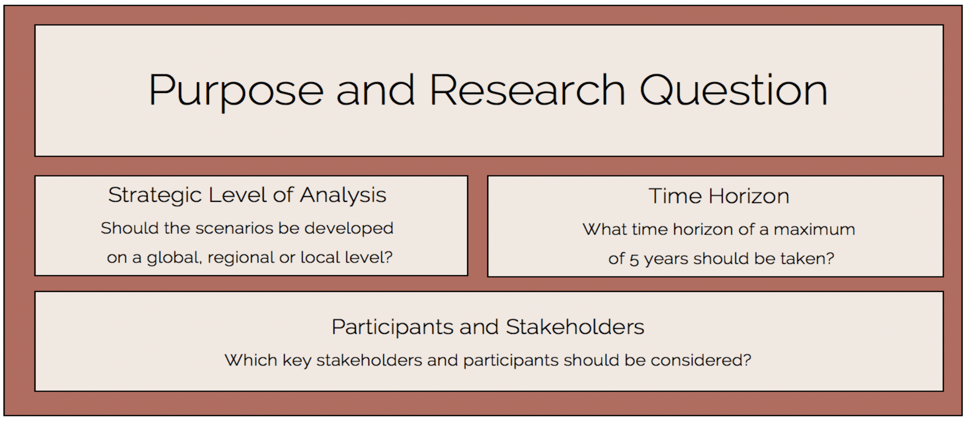

Figure 3.4 Customized Framing Checklist Model inspired by Schwenker and Wulf (2013)

Step 2: 360° Factor Identification

The overall purpose of the second step is to identify key industrial factors. According to Schwenker and Wulf (2013) and Schoemaker (1995), factors should have an impact on the chosen industry. Further, as stated by Schoemaker (1995), key factors could be identified by highlighting the perspectives of the identified stakeholders regarding future development. The factors can therefore suitably be identified by the data collected from qualitative interviews. The identified factors should later be compared with secondary data due to existing benefits of benchmarking stakeholders' assumptions with external perceptions (Schwenker & Wulf, 2013).

Step 3: Trend and Uncertainty Analysis

Trend Identification

The third step focuses on analyzing the previously identified factors to acknowledge which factors that will have a large effect on the chosen field of study and play a crucial role when developing future scenarios, i.e. which factors that can be considered as trends. This step resembles step three in the model by Schwenker and Wulf (2013) and step three/four in Schoemaker's (1995) model. To become a trend, three criteria have to be fulfilled (see Figure 3.5). These criteria are are developed to increase the credibility of the results by combining multiple sources of data.

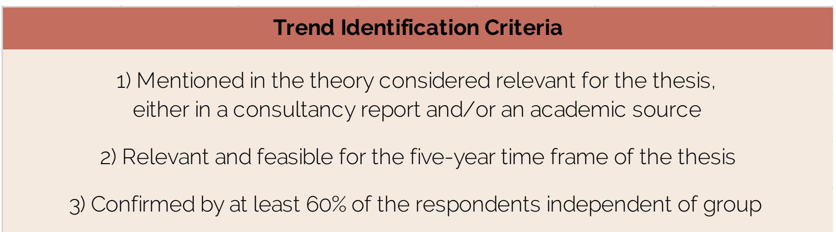

Figure 3.5 Trend Identification Criteria

Perception Analysis- Second Round Questionnaire

After identifying the trends, their possible impact on the future of the industry and their perceived degree of uncertainty should be evaluated, i.e. the trends should be determined as Certain Trends (TC) or Uncertain Trends (TU). A trend is considered being certain if its change is known and continuous (Schoemaker, 1995). If the change is unpredictable, it is classified as an uncertainty (ibid.). To categorize the trends as certain or uncertain, a Perception Analysis should be performed by sending out a survey to the respondents who previously participated in the qualitative parts of the study. The survey should include the previously identified factors, asking the respondents to rate each factor and its perceived level of impact/uncertainty on the industry on a scale from one to ten, where one represents low and ten represents high. Based on the results from the survey, an average of all responses connected to each factor should be calculated. Further, the calculations should be visualized in a customized Impact Uncertainty Grid (see Figure 3.6.), resembling the grid developed by Schwenker and Wulf (2013), where the calculated averages affect their placements in the grid. The customized grid is divided into three different sections, Certain Trends, Uncertain Trends and Secondary Elements which enables a labelling and grouping of the different factors accordingly. Since the range of the y and x axes respectively are between 0-10, the middle value equals 5, which further is the limit to if a trend is considered certain or uncertain. The secondary elements are factors with a minor impact and are therefore not further considered in the coming steps of the study. The Certain Trends (TC) and the Uncertain Trends (TU) are predicted to have a great impact on the field and are therefore continuously used in the following steps.

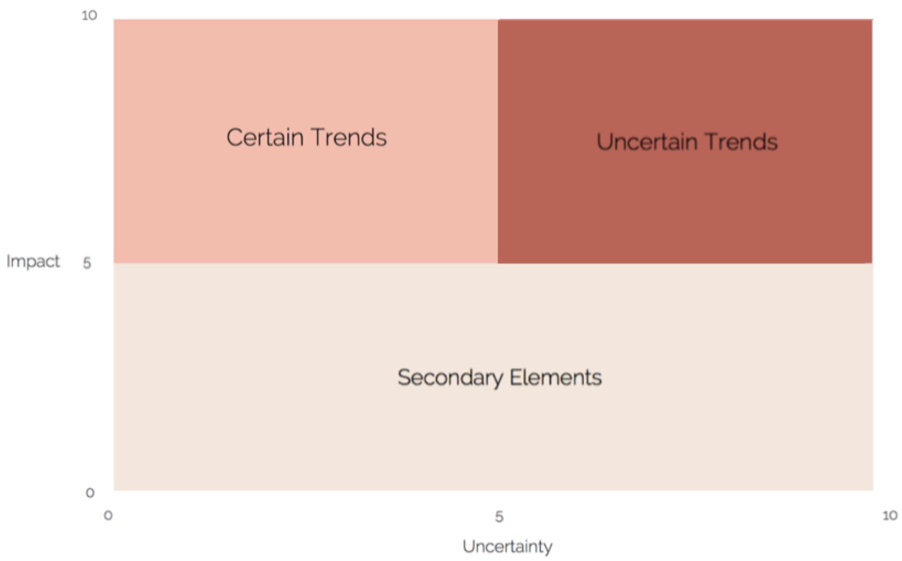

Figure 3.6 Customized Impact and Uncertainty Grid

Uncertainty Correlation Matrix

After identifying the Certain Trends (TC) and Uncertain Trends (TU), the correlation between the Uncertain Trends (TU) needs to be determined before developing the future scenarios in step 4. Schoemaker (1995) argues for this step to be crucial, since all combinations of the Uncertain Trends (TU) may not occur simultaneously. To address the interrelationships between the uncertainties, Schoemaker (1995) suggests to perform a Correlation Matrix. A Correlation Matrix is a table showing correlation coefficients between variables (See Figure 3.7) and should be based on the data received from the quantitative Perception Analysis. A positive correlation (+) indicates a positive relationship between the uncertainties. A negative correlation (–), indicates a negative relationship between the uncertainties in which one variable increases as the other decreases, and vice versa. No correlation (0) and undetermined correlation (?) are two other possible outcomes. The correlation between the variables can be calculated e.g. by using Pearson's r, followed by an internal consistency analysis using Cronbach's Alpha.

Correlation Matrix Template						
	TU1	**TU2**	**TU3**	**TU4**	**TU5**	**TU6**
TU1		+	?	0	+	0
TU2			+	+	+	+
TU3				0	?	+
TU4					+	?
TU5						+

Figure 3.7 Correlation Matrix Template Inspired by Schoemaker (1995)

Step 4: Scenario Development

This step is inspired by the fifth step of Schoemaker (1995) and the fourth step by Schwenker and Wulf (2013). Combined, the two theories state that scenarios should be developed based on the previously identified Certain Trends (TC) and Uncertain Trends (TU), to create four potential future scenarios.

Extreme Values and Scenario Outline

To develop scenarios, the approach of using the Scenario Matrix developed by Schwenker and Wulf (2013) is adopted. The Scenario Matrix consists of four quadrants, one for each scenario (see Figure 3.9). Schwenker and Wulf (2013) highlight four scenarios as being the highest quantity of scenarios that a decision maker can process. To visualize the scenarios, two extreme values should be selected as scenario dimensions. The extreme values should be comprised by the previously identified Uncertain Trends (TU) and two extreme outcomes related to each uncertainty. Thereafter, the identified extreme values should be placed on the x and y axes respectively (see Figure 3.9). The choice of extreme values is based on the criteria presented below in Figure 3.8.

Extreme Value Identification Criteria
1) The uncertainties should jointly have the highest perceived trend influence and uncertainty
2) The uncertainties should have the highest number of mentionings by the respondents
3) The uncertainties should correlate

Figure 3.8 Extreme Value Identification Criteria

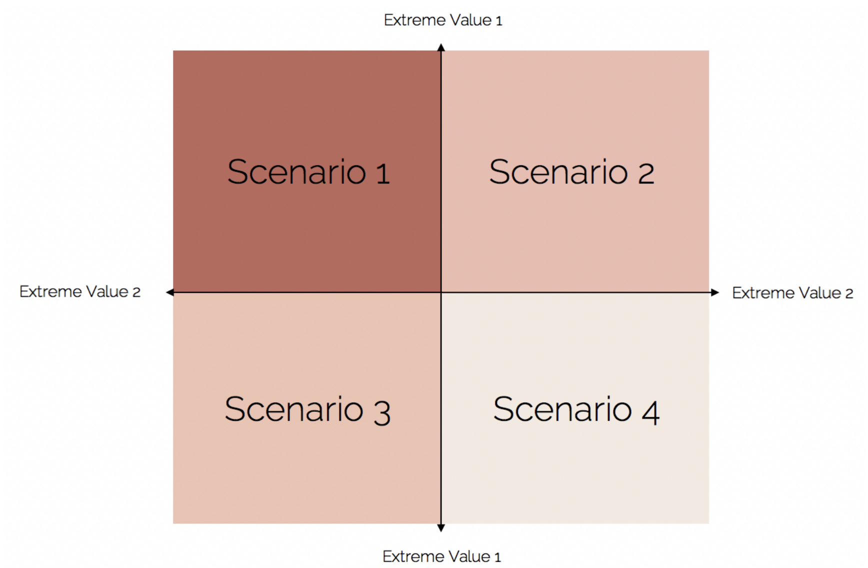

Figure 3.9 Customized Scenario Matrix

Scenario Storylines

When the two extreme values are identified, a storyline connected to each scenario should be constructed. As described by Schwenker and Wulf (2013), the previously identified trends and uncertainties should be included in all scenarios to profoundly explain the future scenarios. Further, all four scenarios should be presented as narratives (Ramirez, Churchhouse, Hoffman & Palermo, 2017) and describe different futures, be feasible and answer the research question (Schoemaker, 1995). Moreover, when developing the storylines, the trends and uncertainties as well as their relationships should be described and visualized through an Influence Diagram (see

Figure 3.10), in line with Schwenker and Wulf (2013). The Influence Diagrams do not display a hierarchical order. Instead, the diagrams describe the most important elements and how they influence each other.

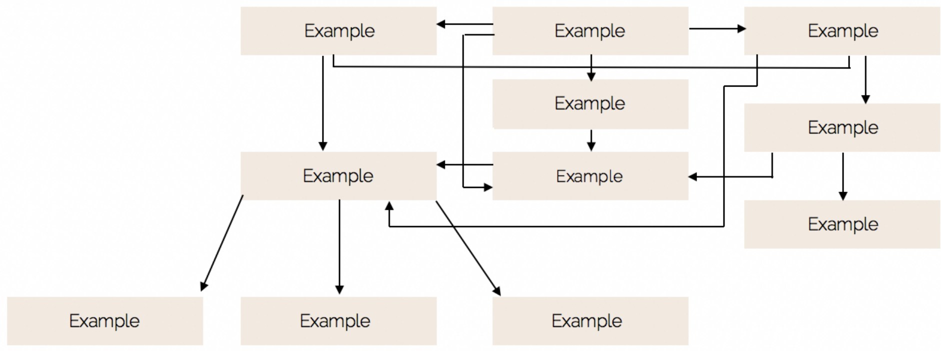

Figure 3.10 Example of Influence Diagram

Step 5: Scenario Learnings and Future Research

This fifth step is based on the seventh and eighth step in the Schoemaker (1995) model, stressing the importance of scenario development being an iterative process. The purpose of this step is to make the model more suitable for academic research. For a model used in academia, it is feasible to develop similar to what Schomaker (1995) identifies as Learning Scenarios, which are scenarios working as a basis for future interesting areas of research. Therefore, this step focuses on identifying learning outcomes from the developed scenarios. Further, for the academic study to make a clear contribution, propositions for future research should be outlined. In order to accomplish scenario learning, Schoemaker (1995) stress the importance of naming the scenarios in Step 4 with inspiring names to make the scenarios more tangible and easier to build upon in future research.

4. Empirical Data

The following chapter serves to present the first two steps of the customized Scenario Planning model, namely Step 1: Definition of Scope and Step 2: 360° Factor Identification. Firstly, a summary of the study's scope will be presented in a Framing Checklist followed by a factor identification, including the most important factors from the qualitative interviews. This chapter will present the main empirical findings. However, to follow the steps of the customized Scenario Planning model, descriptive statistics will also be presented in section 5.1.

4.1 Step 1: Definition of Scope

The scope of the study has been summarized in the Framing Checklist (see Figure 4.1). The overall goal of the project is to identify the future role of ML within the public primary school in Gothenburg by presenting feasible scenarios. Regarding the strategic level of analysis, the study focuses specifically on the city of Gothenburg. Further, the research focuses on ML within the area of the public primary school. In addition, as the participants will be represented by the industries' stakeholders, stakeholders and participants are treated as one group. According to Schoemaker (1995), it is important to include the stakeholders primarily affected by changes in studied field. Therefore, 15 respondents from the sub-groups Education, Expertise and Politics are included (see section 2.3). Lastly, as Schwenker and Wulf (2013) stress that a time horizon should be set between three to five years, this research will use a five year time-horizon.

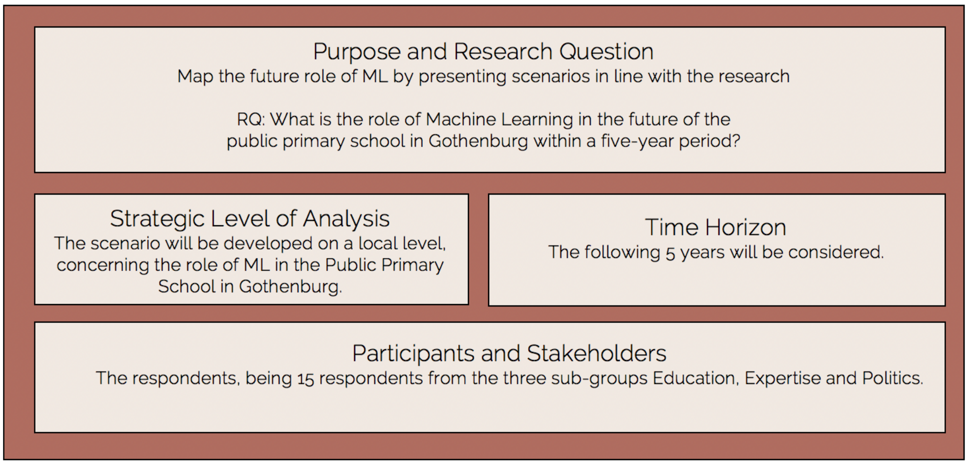

Figure 4.1 Framing Checklist Of The Study Inspired by Schwenker and Wulf (2013)

4.2 Step 2: 360° Factor Identification

In Step 2, key industrial factors will be identified by using primary data collected from the performed interviews. The identified factors are presented in Table 4.1, Table 4.2 and Table 4.3 and are divided by respondent and respondent sub-group. Further, the identified factors are described according to the empirical data drawn from the qualitative interviews. The factors will later function as a basis for the trend and uncertainty analysis in Step 3 (see section 5.1).

Respondents Education						
Identified Factors	Lindblad	Stigert	Student G3	Student G9	Fredriksson	Hammarqvist
Demand	M		M	M		M
Time Perspective	M	M		M	M	M
Lack of Resources	M	M			M	
Technical Infrastructure	M	M	M	M		M
Combined Usage	M	M	M	M		M
Inequality	M			M		
Knowledge and Research	M	M			M	M
Regulations	M	M			M	M
Expectations and Potential	M					M
Adaptive Learning	M	M	M			
Teacher's Role	M		M	M	M	M
Supply		M			M	
Inertia	M	M			M	
Usage		M	M	M	M	M
Prioritization						
Shortages and Vagueness	M	M				M
Data Boom						
Future Educational Challenges				M		
Quality		M		M	M	M
Resistance Towards Change						
Costs						
Structural Challenges						
Sceptisism		M				
Beneficital for Weaker Parties	M					
Time Consuming						M

Table 4.1 Factor Identification Education

Respondents Education						
Identified Factors	**Lindblad**	**Stigert**	**Student G3**	**Student G9**	**Fredriksson**	**Hammarqvist**
Demand	M		M	M		M
Time Perspective	M	M		M	M	M
Lack of Resources	M	M			M	
Technical Infrastructure	M	M	M	M		M
Combined Usage	M	M	M	M		M
Inequality	M			M		
Knowledge and Research	M	M			M	M
Regulations	M	M			M	M
Expectations and Potential	M					M
Adaptive Learning	M	M	M			
Teacher's Role	M		M	M	M	M
Supply		M			M	
Inertia	M	M			M	
Usage		M	M	M	M	M
Prioritization						
Shortages and Vagueness	M	M				M
Data Boom						
Future Educational Challenges				M		
Quality		M		M	M	M
Resistance Towards Change						
Costs						
Structural Challenges						
Sceptisism		M				
Beneficial for Weaker Parties	M					
Time Consuming						M

Table 4.2 Factor Identification Expertise

Respondents Politics		
Identified Factors	**Broman**	**Wikström**
Demand		M
Time Perspective	M	M
Lack of Resources	M	M
Technical Infrastructure	M	M
Combined Usage	M	M
Inequality	M	M
Knowledge and Research	M	M
Regulations	M	M
Expectations and Potential	M	
Adaptive Learning		M
Teacher's Role	M	M
Supply		
Inertia		
Usage		M
Prioritization		
Shortages and Vagueness	M	M
Data Boom		
Future Educational Challenges		
Quality	M	M
Resistance Towards Change	M	M
Costs		
Structural Challenges		
Sceptisism		
Beneficital for Weaker Parties	M	M
Time Consuming		M

Table 4.3 Factor Identification Politics

Demand- Ten of the respondents describe an increasing demand for AI and ML, highlighting that it has and will continue to have a crucial impact on the industry of education. According to Heintz, the main reason for the increased demand is due to increased investments and knowledge. Furthermore, Masiello highlights that one of the main reasons for the increasing demand is that it has become more coercive since the increased regulatory focus on digitalization is pushing the schools towards an increased digital usage. Lundin also highlights an increased demand, describing a current cycle of hype initiated by improved technology and success stories related to the technology of ML. According to Lundin, the field has previously been through similar cycles which have ended with the success stories being unreachable. Further, Lundin describes that what differentiates this wave from the previous is the availability of large data sets, arguing for a different type of cycle. Moreover, Sörensson describes the demand for ML-based tools related to school activities taking place outside of school, e.g. homework, as being larger than the demand for ML when regarding classroom-based activities. Wikström also describes a high demand, highlighting that many stakeholders have recently realized the great potential of using digital tools. Further, Heinz argues that authorities show great interest and that recently employed regulations have had a large impact on the increasing demand. When regarding a company perspective, Anonymous argue that the increased demand will continue to rise in parallel with increased research and evidence. Both Student Grade 9 and Student Grade 3 highlight an increased usage and need for involving digital tools in the education both as it is practical and more engaging.

Time Perspective- In the Education group, all respondents consider the tools available on the market as short-term due to a lack of support and after-services. Regarding the demand side, Stigert mentions that the companies clearly have a business focus, leading to a clash between the supply and the schools' needs. Further, as argued by Heintz, many of the efforts implemented in the schools are halfway solutions, while more long-term solutions and clearer developed systems would be preferable. For the digitalization of education to create more value, Heintz argues for the need of an ecosystem, i.e. that digitalization should become a more integrated part of the system, instead of a separate short-term solution. Additionally, Masiello describes a short-term focus in relation to regulations, arguing that new strategic plans implemented by the government are lacking in providing guidelines of how to be employed.

Lack of Resources- According to Lindblad, parts of Gothenburg are experiencing a lack of resources both in regards to economic assets and a shortage in teachers. This has resulted in a limited and unsuccessful usage of digital tools. According to Stigert, despite a relatively tight budget, authorities have some discretionary power over the budget, currently forcing the schools to invest in digital solutions. Heintz states that the budget is restricting the usage of digital tools in schools and that large investments will be a future necessity to avoid short-term solutions. Kristoffersson discusses resources from a company perspective, highlighting that due to a lack of resources within the educational sector, the profit margins are low, hampering the development of ML-based tools. All respondents from the group Politics agreed with the issues related to a lack of resources. According to Wikström, economic restrictions have an impact on ML's implementation as almost every decision is partly viewed from a cost perspective. However, Wikström believes that restrictions are not necessarily negative since it enhances thoughtfulness.

Technical Infrastructure- All respondents in the group Education describe problems related to the currently lacking technical infrastructure in Gothenburg, since it hinders the schools from using available tools. According to Stigert and Lindblad, the lacking infrastructure is a hurdle stifling the future implementation of digital tools. Student Grade 9 argues that the technical infrastructure impacts the current digital usage, often due to problems related to the Wi-Fi. Respondents from the Education group describe difficulties in providing each child a laptop since it requires enormous efforts in technical infrastructure. According to Lindblad, many schools have poor Wi-Fi and cannot offer all their students a computer/iPad. In parallel, Broman argues that large scale investments such as providing one laptop per child will be important for a future increased digital usage, which will require large investments in technical infrastructure.

Combined Usage- Opinions regarding the benefits of using digital tools as a complement to more traditional tools were especially evident in the group Education, where all respondents considered it being a beneficial way to integrate digital tools in the current way of teaching. Fredriksson states that using digital tools as a complement would be beneficial as it might be risky to delegate the teaching entirely to machines. Further, Hammarqvist highlighted the need for social interaction. In parallel, both Student Grade 3 and Student Grade 9 highlight the importance of the teacher as a complement to digital usage. Additionally, Student Grade 3 argues that the teacher is essential for a calm and quiet classroom and to understand the students' needs. Stigert however, understands the need for teaching students how to use all types of digital tools but is skeptical towards learning younger primary school students the basics such as reading by using machines.

When regarding the group Expertise, Lundin highlights the usage of ML as a complement supporting teachers in areas such as administration, enabling them to focus on their core tasks. Further, Sörensson mention the importance of grasping that high tech does not have to come at the expense of low tech, but instead, the two can function efficiently together, especially in the transition towards a more digitized education system. Kristoffersson describes his future dream scenario being to complement the human interaction where teachers and students interact and stimulate each other with digital tools, helping each student to reach its full potential.

Inequality- All three respondent sub-groups address the inequality present amongst the schools in Gothenburg, described as being connected to e.g. the poor infrastructure. Wikström describes a new initiative in Gothenburg, where the focus has been to centralize the decision making to one central Board of Primary Education with authority over all regions in Gothenburg. Accordingly, one of the main goals is to create more equality between the schools in Gothenburg. In addition, Student Grade 9 notices inequalities when comparing the usage of digital tools amongst districts. Lundin and Broman state the importance of taking the inequalities between students into consideration since an increased usage of digital tools requires sufficient technical infrastructure both at home and in school. Masiello however, argues for a resource inequality, and the fact that schools with lacking resources prioritize other things than digital tools, leading to additional equalities.

Knowledge and Research- When regarding the group Education, a common viewpoint was the demand for more research and proven results for a future increased usage of digital tools, including tools based on ML. In particular, the respondents described a demand for research proving the benefits of including digital tools in general and ML-based tools in particular in teaching. According to Lindblad, all schools would benefit from increased knowledge, having the possibility to access knowledge indicating which types of tools that are considered beneficial to use. Moreover, Anonymous states that one of their largest company challenges is to educate their customers about their ML technology. Masiello stresses that Sweden is lacking in basic research, partly due to a current need to prioritize other areas where the school is currently lacking. He further states that the implementation of ML-based tools in the public primary education will continue being inert until researchers begin to focus on a more long-term and sustainable perspective as the future benefits and areas of use are ambiguous. Heintz agrees, stating that Sweden has not invested enough in basic research, creating a national lack of competence. In parallel, Kristoffersson highlights the need for more research as the rapid AI development is problematic as its outcome is depending on all stakeholders understanding AIs' possibilities and risks.

"Science gathers knowledge faster than society gathers wisdom"- Kristoffersson

Further, the respondents describe many principals and teachers to have deficient knowledge regarding how to use digital tools, both when regarding teaching and administrative tasks. Heintz argues that this issue springs from the educations in Sweden being too narrow, believing that all types of educations, including the teacher education program, needs to be broader and include additional areas as it would enhance the understanding of the present society. In parallel, both Masiello and Fredriksson agree, highlighting that the teacher education program does include sufficient teaching of digital features. Melin, agrees, discussing the teachers' knowledge to be critical for the future development. In addition, a knowledge gap is said to exist between the schools' expected demand and their actual demand, resulting in the available products being developed in a way considered inappropriate from a school perspective. Lundin agrees, stating that one challenge is that the developers of the systems are lacking knowledge regarding how the schools work, often resulting in schools investing in products which they do not know how to use.

Regulations- One of the most frequently mentioned factors affecting the future role of ML is the case of regulations. Many of the respondents highlight the importance of regulations since it impacts the digitization of the public primary school, one example being the changed curriculum, focusing on increased integration of digitalization and including programming as a mandatory subject. Masiello states that these types of regulations result in a coercive demand, since the actors are required to implement digital elements in the teaching, leading to an increased demand for products and knowledge. Lundin argues that the efforts already implemented, such as the Digiplan, are beneficial. However, he believes that the schools need clearer guidelines partly due to the principals' lack of knowledge.

Heintz argues that the current curriculum is open for misunderstandings and different interpretations. Further, from a company perspective, the representatives argue that the educational industry is slow and conservative, why national regulations are needed to push the development forward, something that is currently lacking, especially regarding security aspects. In addition, Kristoffersson argues that the private companies experience a skewed competition, since some regulations force the schools to use tools originating from public actors, why Kristoffersson believes that the market would flourish if the competition became more open and fair. Lastly, Stigert argues that regulations can impact the schools' financial assets in terms of budgeting. Lindblad agrees, stating that economical aspects play a large role in the implementation and usage of digital tools.

Expectations and Potential- Several respondents describe a skepticism towards the possibilities of an increased usage of ML. According to Anonymous, ML-based tools are currently limited despite a great number of products available on the market, wherefore a noticeable change within the coming five years is considered unlikely. However, Anonymous highlights that we will experience a future improved ML technology and increased usage within fields such as private education and application usage, especially within language and maths. Fredriksson expects that people will realize that digitalization might not be the solution to everything, wherefore she expects a future enhanced balance between the usage of digital and analogue tools. Lundin argues that since the producers of teaching materials are increasingly offering tools based on the technology of ML, he believes that the supply will continue to increase. According to Heintz, ML will continue to be part of the future solutions but does not believe that the explicit usage will increase noticeably in a five-year period. In addition, Heintz and Kristoffersson expects tools including ML to play an important role within the school's administration and organization. However, Kristoffersson states that a five-year time period is too short for an apparent difference in terms of a widespread usage of ML within the area of learning, but believes that ML will continue to be present within profiling. Further, Masiello states that in a five-year period, he expects an increase in evidence and research but not a major change when regarding increased usage in the public primary schools. Sörensson on the other hand believes that we definitely will be able to notice an industrial change within a five-year period.

Further, many of the respondents highlight that the technology of ML has the potential to make the public primary school more adaptive. Melin highlights that ML and AI will play an important role in making the school more adaptive. However, Melin expresses his skepticism towards if the development will have come that far within a five-year period. When regarding the group Politics, Wikström, in a five-year period, expects the Swedish school system to be more equal and that every student will be able to have a greater understanding of what they need to improve.

Adaptive Learning- Another factor mentioned by respondents from all sub-groups is the possibility to make the teaching more adaptive, both when using digital tools in general and ML-based tools in particular. Student Grade 3 describes a demand for adaptive learning, desiring more challenging assignments in school. Respondents from the group Expertise describe adaptive learning as beneficial, making the education more effective while simultaneously enabling important extra time for the teachers. Adaptive learning would further enable every student to work on tasks adapted for their individual learning curve. Kristoffersson argues that the greatest long-term win considering educational digitalization are the possibilities related to adaptive learning.

"If one is to look at the long-term effects of including ML in teaching, it would be that one can individualize the learning on a large scale and experience improved learning in an improved way. After all, this is without a doubt its great potential." - Kristoffersson

Important to notice however, as mentioned by Anonymous, is that ML-based tools are considered beneficial but not required to achieve adaptive learning. At times, Anonymous stresses, more basic digital tools are sufficient. Further, Lundin argues that it is possible to develop adaptive educational systems without using ML technology. As opposed to the positive viewpoints of a more adaptive learning process, the two principals interviewed are more skeptical about making the Swedish school too individualistic, where Stigert blames the individualism for the Swedish schools' deteriorating results. However, Stigert believes that some positive aspects are connected to adaptive learning, even if he highlights that the teaching process should not be individualized. Lindblad agrees, highlighting the power of the group when regarding the learning.

"The education should not be more individualistic in general, but it could be beneficial to individually adapt certain assignments"- Stigert

Teacher's Role- Respondents highlighted the teacher's role as continuously crucial in a potentially more digitized school environment. According to Lindblad, the teachers are currently relatively autonomous, having the possibility of choosing their preferred teaching materials wherefore the number of digital tools used in schools are dependent on the interest and knowledge of the teacher. Broman agrees, further stating that this might have a negative impact on equality amongst the schools in Gothenburg. In the group Education, both Student Grade 3 and Student Grade 9 stress the role of the teacher being a necessity for the students to handle digital tools correctly and to create order in the classroom. Fredriksson does not believe that it would be suitable to hand over the teaching to machines, wherefore she states that the teacher's role will be more demanding in the future. Lundin, believes that we will see a future development of methods for teachers to work together with digital support.

"We are definitely not here to replace the teacher. We are here to facilitate and empower the areas where the teacher is proficient"-Anonymous

Heintz describes that future gains are to be found amongst the administrative tasks, as an increased usage of ML might decrease the teacher's focus on administrative tasks. In addition, Hammarqvist highlights the advantages of decreasing the administrative focus. Masiello highlights that since knowledge is available online, the future role of the teacher will be more coaching. Furthermore, Sörensson describes that a future increased usage of AI will demand the teachers to reconsider their current way of working.

”I consider it being a pedagogical revolution, a whole new way of working”- Sörensson

Supply- Both the group Expertise and Education argue for a growing market for ML-based tools. However, Stigert argues for a short-term focus amongst the companies on the market due to the companies´ lacking knowledge regarding the schools' needs and demands. In addition, Stigert mentions an increased pressure from companies to employ digital tools. The respondents from the Expertise group provide a different perspective, describing an increased supply due to the greater possibilities of returns compared to before. Masiello also highlight a conflict between the demand side and supply side, where the lack of a long-term and sustainable solution plays a crucial role. According to Masiello, a successful future company needs to offer a long-terms service, not just a short-term product, in order to fill this gap.

"The companies are pushing the schools to buy whatever is the cheapest tools at the market." - Masiello

In a future state, Sörensson believes that the market will grow and face a turning point where actors realize the positive aspects related to high-tech educational tools. Continuously, from a company perspective, Kristoffersson argues that the current competition, and hence the current supply, is limited, if not absent. He believes that this is partly due to rules provided by the Swedish National Agency for Education's rules, encouraging schools to adapt certain types of tools, leading to a skewed competition. Anonymous further argues for the relatively low competition and supply, despite the increasing demand. However, Anonymous believes the market for ML to grow in a near future.

Inertia- The respondents describe the school system as conservative and inert, with accustomed working patterns, stifling the possibilities of innovation. Heintz agrees with the industry being inert, meaning that the inertia is due to a lack of research and knowledge. However, some respondents describe potential benefits with a somewhat inert school system. Lundin, argues that the public-sector benefits from being somewhat inert and thoughtful before implementing change due to consequences induced by improper decisions. Kristoffersson argues for an inertia due to the teachers' authority regarding planning and executing lectures, resulting in no common standards and a general skepticism towards digital tools.

In addition, Fredriksson, argues for inertia within the teachers' program, which she believes to enhance industrial inertia. For example, although the examination goals were changed recently, it only occurs every 10 years. Sörensson presents another viewpoint, arguing for inertia due to a lack of actors at the market. Sörensson describes that since the educational system is old and accustomed, changes occur slowly, why an increased number of actors on the market would possibly lead to faster implementation of change within the industry. Therefore, new and re-thinking actors could contribute to developing the future school system.

Usage- Respondents from all sub-groups mention how digital tools are used on a daily basis in Gothenburg. However, the usage of tools incorporating the technology of ML is limited or non-existing. Further, it is evident that the usage is dependent upon district and school. Student Grade 9 mentions that her school provides one computer per child, while her friends other schools do not use computers at all. In addition, the usage is also dependent upon the teachers' and principals' own interests, where for example Stigert states that his school does not use computers and digital tools, partly due to his skeptical mindset. The current goal, and the most effective way to implement digital tools is according to Wikström and Broman to adapt the system of providing one computer per child, albeit in later ages, preferably in the upper level secondary school. Moreover, it would be beneficial if all schools used the same administrative software tools. Additionally, many of the respondents mention that the greatest profits will arise from digital tools to remedy the administrative tasks as opposed to a learning purpose. Heintz for example states that the advancements will primarily favor the administrative tasks, tasks such as attendance reporting, and thereby release more valuable time for the teachers.

Prioritization- According to Masiello, one factor impacting the incorporation of ML within the Swedish public primary school is the schools' current need for prioritizing other more urgent areas such as how to handle the lack of teachers. Masiello states that the technology of ML will not be used on a larger scale until other vital problems have been solved.

Shortage and Vagueness- Lundin describes his skepticism of defining AI in terms of human cognition. According to Lundin, this type of definition might result in the creation of a misleading image of the greatness of ML as the technology currently cannot perform the same tasks as humans. Further, both Stigert and Lindblad highlight the vagueness of proven results regarding the appropriate way of incorporating ML in the current teaching. Lundin states that a future challenge for companies providing ML-based tools is to access the large amount of data necessary for the technology to function, especially when people are beginning to understand the value of their personal data. Another shortage was mentioned by three respondents in the group Expertise, highlighting cultural bias as a significant challenge. Both Lundin and Heintz stress that cultural bias will become an increasingly larger issue in parallel with an increased usage of ML. Additionally, Fredriksson describes that the usage of ML comes with additional challenges e.g. related to specific regulations such as GDPR. The fact that some of the tools are not adapted for these regulations limits the pool of appropriate tools. Lastly, another shortage described is related to the complexity of the ML technology. As mentioned by Masiello, the ML technology is considered being too complicated by its users. Therefore, the industry would benefit from describing ML in different terms. Masiello further believes that the companies working with ML within the field of education would benefit from focusing on the pedagogical benefits of the tools instead of the technical benefits to create a broader interest.

Data Boom- Anonymous argues for a current data-boom leading to an increased digitalization, where all industries, including the educational, are encouraged to collect valuable data. To organize the data, ML is considered needed.

Future Educational Challenges- Several of the respondents highlight that an increased usage of ML-based tools in the public primary school would result in future educational challenges including the future shaping of the classroom. Lundin highlights that if ML-based tools would become widespread within Swedish education, it would result in an increased spread in the students' levels of knowledge due to increased adaptivity. Moreover, this would result in a need for a reorganization of the traditional idea of grouping students of similar age in the same class. Instead, Lundin exemplifies that a future way to group students would be by reviewing their level of knowledge.

Quality- Many of the respondents highlight the importance of the digital tools' quality and functionality. The respondents from the Politics group stress the importance of securing the quality of digital tools. According to Broman, all stakeholders would benefit from a more extensive process in securing the products' quality, stating that it is not publicly known which tools that have been audited. Wikström states that one of the main improvement areas currently focused upon is increased educational quality wherefore many decisions are made to reach this goal. Wikström argues that there are many ML-based tools which are not good enough in terms of quality. However, he also states that this is the case even with more traditional tools. Sörensson agrees, stating that there are no available ML tools that can be considered as a well-functioning and fully-developed teaching material. In addition, Sörensson believes that the number of actors will have to increase for the tools to improve.

In the group Education, many respondents stress the need for tools being well-functioning. Hammarqvist states that if the tools are not working properly it impacts the entire classroom, steeling time from the teacher. Further, Fredriksson argues that an increased usage of digital tools in general and ML based tools in particular does not equal an increased educational quality as it is dependent on other factors such as the quality of the utilized tools and how the teacher would incorporate it in the teaching. From a student perspective, Student Class 9 describes that when currently used digital tools stops functioning, it takes a long time before the tool is fixed.

Resistance Towards Change- Broman argues for a resistance towards change amongst the teachers. Broman believes that some of the resistance is dependent on that many stakeholders believe that the school either has to be very digitized or analogue, when a combination of them both would be a feasible solution. According to Wikström, there is an inherent resistance towards change among the teachers, why the Board of Primary Education has inspirational meetings and offers education to encourage and motivate an increased usage of digital tools. Currently, a majority of teachers believe the tools to be too complicated to use and that the solutions are developed to decrease the teaching instead of increasing it. Therefore, Wikström believes that education and knowledge are important factors to decrease the resistance towards change. In addition, due to the resistance of the teachers, the tools need to be easy to understand to decrease the resistance.

Costs- Sörensson highlights that the implementation of ML and other digital tools is partly dependent on its costs. Lindblad and Stigert agrees, stating that investing in digital tools often comes with costs in addition to the initial investment related to e.g. service and support. However, Lundin stresses that the technology of today is relatively cheap. Further, he believes that many schools buy hardware to save money as it is more expensive and sometimes more difficult to hire an additional teacher. In parallel, Masiello describes that the reason for the limited usage of ML in the public primary school is not primarily related to costs but to a lack of knowledge.

Structural Challenges- Heintz states that the educational industry is difficult to enter due to many structural challenges making it difficult to implement new and innovative solutions. Further, due to the complex system, improving one part of the educational sector might transport the problem elsewhere, why fundamental changes are needed for a more widespread usage of ML-based tools. Therefore, providing tools benefiting many students would be preferable. If not, long term improvements will not be reached.

"We need to build an ecosystem instead of developing single products." - Heintz.

Skepticism- Stigert is not convinced about the digital tools' superiority over traditional tools when regarding the teaching of the basics such as e.g. reading, writing and counting. Stigert further describes that the demand side is skeptical, doubting the functional and pedagogical aspects of the digital tools in general. However, other interviews, mainly in the group Education, bear witness to an underlying skepticism. For example, Fredriksson states that an increased digitization would not necessarily result in a higher quality education. Sörensson describes a great resistance towards digitalizing educational materials from the public sector and Lindblad stresses that many see digital tools as the savior of the Swedish school system, which she does not agree with. Lastly, Student Grade 9 is positive towards a certain degree of digitization but insinuates a certain skepticism towards if it is suitable for all students since many chooses digital tools due to them being lazy.

Beneficial for Weaker Parties- Digital tools in general and ML tools in particular are considered beneficial for weaker parties such as students who cannot attend school and children with functional variations. Sörensson argues for an increased possibility for motivation, which Lundin agrees with, mentioning the fact that all students can work with exercises adapted for their individual level. Lindblad and Wikström both discuss the possibilities that for example robotics brings for students choosing to stay home, even if it might decrease their incentives of going to school.

Time Consuming- Hammarqvist highlights that creating an understanding for ML and other digital tools is time-consuming and that the current lack of teachers and large number of students per teacher makes is difficult to focus on an unfamiliar topic. Hammarqvist considers it time consuming to understand how the tools work but also how to incorporate them in the current way of teaching. Wikström believes that the lack of time limits an increased adoption of digital tools. Wikström further argues that teachers tend to reject using digital solutions as they do not have the time to actually understand how they work.

5. Analysis

In the following chapter, Step 3 in the customized Scenario Planning model will be presented, namely: Trend and Uncertainty Analysis. The chapter commences with a trend identification. Further, the identified trends have been evaluated in a survey and will be defined as Certain Trends (TC) or Uncertain Trends (TU), constituting the basis of a Perception Analysis and an Impact and Uncertainty Grid. Thereafter, descriptive statistics is presented and discussed. Lastly, all trends will be analyzed, followed by a correlation analysis.

5.1 Step 3: Trend and Uncertainty Analysis

Trend Identification

The following section enables the researchers to answer the two questions subordinating the research question, namely, what trends and uncertainties that can be identified as important for the future role of ML in the public primary school in the city of Gothenburg. With the respondent data presented in the previous chapter, four predetermined criteria are taken into consideration (see Figure 3.5) to decide which of the factors identified in the previous sections that can be defined as trends. Based on the criteria, 11 of the factors were identified as trends, namely, Demand, Time Perspective, Technical Infrastructure, Combined Usage, Research and Knowledge, Regulations, Adaptive Learning, Teacher's Role, Shortages and Vagueness, Inertia and Usage (see Table 5.1). Further, the Certain Trends (TC) and Uncertain Trends (TU) are visualized described in Figure 5.1.

Factor	Mentioned in the theory considered relevant for the thesis	Confirmed by at least 60% of the respondents independent of group	Relevant and feasible for the five year time frame of the thesis	Trend?
Demand	X	X	X	X
Time Perspective	X	X	X	X
Lack of Resources	X		X	
Technical Infrastructure	X	X	X	X
Combined Usage	X	X	X	X
Inequality	X		X	
Knowledge and Research	X	X	X	X
Regulations	X	X	X	X
Expectations and Potential	X			
Adaptive Learning	X	X	X	X
Teacher's Role	X	X	X	X
Supply	X		X	
Inertia	X	X	X	X
Usage	X	X	X	X
Prioritization			X	
Complicated Technology	X		X	
Shortages and Vagueness	X	X	X	X
Data Boom	X		X	
Future Educational Challenges	X		X	
Quality			X	
Resistance Towards Change	X		X	
Costs	X		X	
Structural Challenges	X			
Skepticism	X		X	
Beneficital for Weaker Parties	X		X	
Time Consuming	X		X	

Table 5.1 Trend Identification

Perception analysis

As argued for in section 3.3.2, a Perception Analysis has been conducted to obtain an objective result regarding which of the 11 trends that can be considered as Certain Trends (TC) and Uncertain Trends (TU). The Perception Analysis is based on the results from a survey sent to the respondents previously included in the interviews. The respondents answered two questions and were asked to rank the trends' perceived future impact and uncertainty level on a Likert scale ranging from 1-10 (see Appendix 2). The respondents' answers (R1-R9) and the calculated averages (Avg) are presented below in Table 5.2 and Table 5.3. The trend impact values are presented in Table 5.2 while the uncertainty values are presented in Table 5.3.

Perception Analysis Trend Influence											
Identified Key Factors	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**Sum**	**Avg**
Demand	8	7	10	7	6	8	3	5	10	64	7,1
Time Perspective	6	6	7	8	9	8	5	7	7	63	7,0
Technical Infrastructure	5	5	3	5	8	9	7	7	6	55	6,1
Combined Usage	9	5	5	7	6	9	6	4	9	60	6,7
Research and Knowledge	7	7	7	8	8	9	6	5	7	64	7,1
Regulations	8	6	3	7	8	6	7	5	6	56	6,2
Adaptive Learning	8	8	7	9	6	9	6	6	8	67	7,4
The Teacher's Role	5	9	9	9	6	6	9	6	9	68	7,6
Shortages and Vaguness	8	5	3	4	6	8	8	7	9	58	6,4
Inertia	7	8	2	5	7	7	8	8	7	59	6,6
Usage	7	5	4	8	7	7	8	5	9	60	6,7

Table 5.2 Perception Analysis Summary Trend Impact

Perception Analysis Perceived Uncertainty											
Identified Key Factors	**R1**	**R2**	**R3**	**R4**	**R5**	**R6**	**R7**	**R8**	**R9**	**Sum**	**Avg**
Demand	3	3	1	9	7	5	5	7	1	41	4.6
Time Perspective	3	4	3	7	7	5	6	6	3	44	4.9
Technical Infrastructure	3	6	3	6	7	8	6	4	5	48	5.3
Combined Usage	2	3	3	9	7	4	7	3	2	40	4.4
Research and Knowledge	5	4	6	7	7	6	6	5	4	50	5,6
Regulations	4	3	6	7	7	6	5	4	5	47	5.2
Adaptive Learning	2	4	3	9	7	3	6	7	3	44	4.9
The Teacher's Role	4	2	1	9	7	6	1	5	2	37	4,1
Shortages and Vaguness	5	3	2	3	7	7	3	3	7	40	4.4
Inertia	4	3	3	3	7	5	3	3	6	37	4.1
Usage	2	3	1	9	7	4	4	6	4	40	4.4

Table 5.3 Perception Analysis Summary Trend Uncertainty

The respondents' answers function as a basis for the development of an Impact and Uncertainty Grid. Here, an average of the respondents' rankings (Avg) of the 11 factors of each question influence where they are plotted in the Impact and Uncertainty Grid (see Figure 5.2). Referring to the Impact and Uncertainty Grid, a factor is defined as a Certain Trend (TC) if its y-value (Uncertainty) is > 5 while simultaneously its x-value (Impact) is < 5. A factor is defined as an Uncertain Trend (TU) if the y-value and the x-value are > 5. With the values derived from Table 5.2 and Table 5.3 as a basis, one can conclude that eight of the 11 identified trends can be considered as Certain Trends (TC) and three as Uncertain Trends (TU). A summary of the trends and uncertainties and their average x-values and y-values is presented in Figure 5.1. These values are further visualized in the Impact and Uncertainty Grid (See Figure 5.2).

Trend and Uncertainty Summary
TC1 Demand (7.1; 4.6)
TC2 Time Perspective (7.0; 4.9)
TC3 Combined Usage (6.7; 4.4)
TC4 Adaptive Learning (7.4; 4.9)
TC5 Teacher's Role (7.6; 4.1)
TC6 Shortages and Vagueness (6,4: 4,4)
TC7 Inertia (6.6; 4.1)
TC8 Usage (6.7; 4.4)
TU1 Technical Infrastructure (6.1; 5.3)
TU2 Knowledge and Research (7.1; 5.6)
TU3 Regulations (6,2; 5,2)

Figure 5.1 Trend and Uncertainty Summary

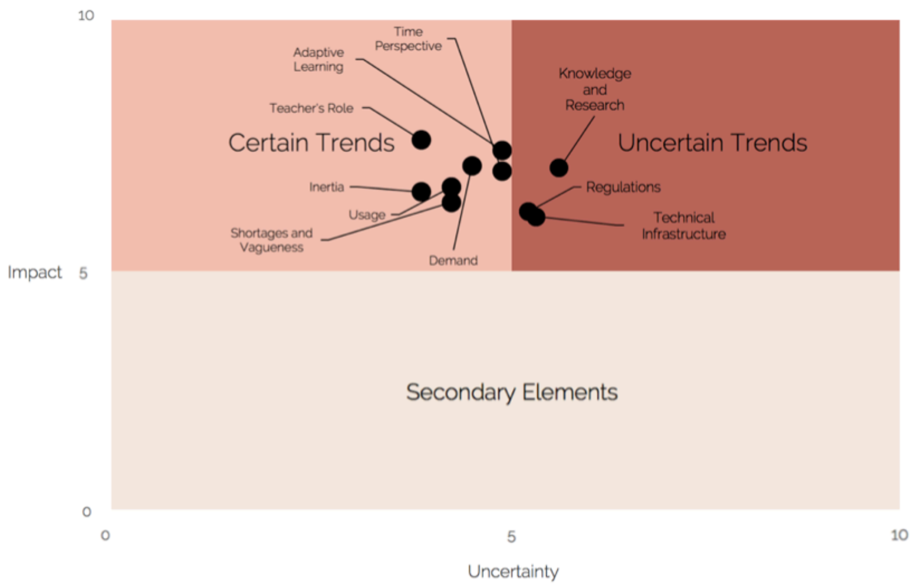

Figure 5.2 Impact and Uncertainty Grid of TC and TU

When reviewing the Impact and Uncertainty Grid (Figure 5.2), one can notice that all trends are plotted relatively centered, with averages between 6,1 and 7,6 on the y-axis and 4,1 and 5,6 on the x-axis. Moreover, it is important to acknowledge that two of the trends have a perceived uncertainty of 4,9 (see Figure 5.1), meaning that they almost classified as Uncertain Trends (TU). However, important to understand is that all trends will be part of the future development of scenarios wherefore their perceived impact and uncertainty will still be taken into consideration in further stages. Further, the centering of the trends might be a result related to the difficulties for the respondents to forecast the future, wherefore providing rather similar answers of all trends might be considered as a safe answer. However, the fact that all trends are considered having a high impact on the future of the industry and that no trends were plotted as Secondary Elements in the grid (Figure 5.2), indicates that the researchers have identified important trends for the future role of ML within the public primary school in Gothenburg.

By reviewing Figure 5.3 and Figure 5.4 below, one can observe the difference between a trend's perceived impact and uncertainty averages. Further Figure 5.3 and Figure 5.4 bear witness to that despite observed similarities amongst the trends, some distinguish themselves from the mass. For example, the trend Teacher's role has the highest impact and a low perceived uncertainty, indicating that the future role of the teacher will continue to be crucial and have a large impact on the educational industry (see Figure 5.4). The same goes for the trend Demand, which high impact and low perceived uncertainty indicates a more certain future development (see Figure 5.3).

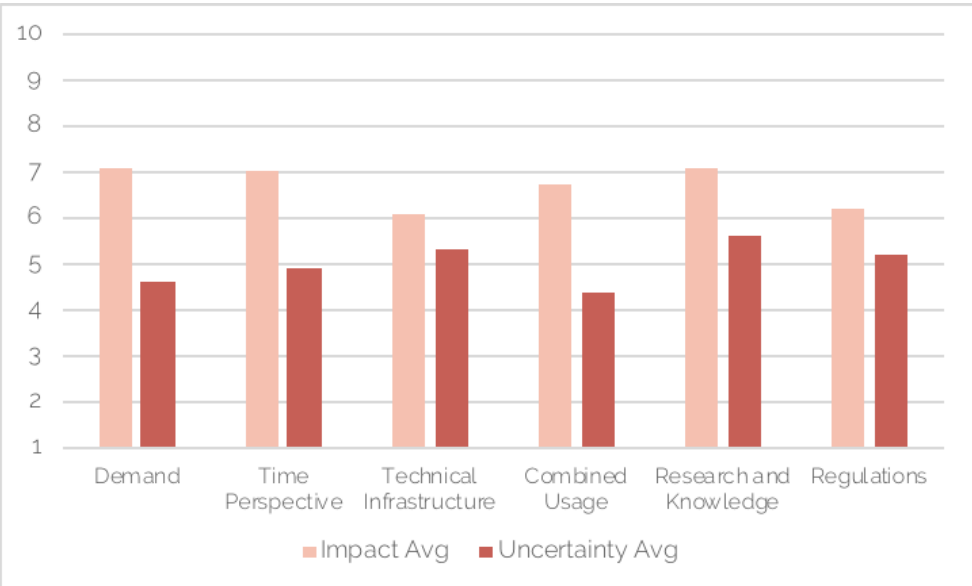

Figure 5.3 Comparison of Trends' Impact and Uncertainty 1

Figure 5.4 Comparison of Trends' Impact and Uncertainty 2

Certain Trend (TC) Analysis

In the following paragraphs, the identified 8 Certain Trends (TC) will be further analyzed, taking both the empirical findings (chapter 4) and the theoretical framework (chapter 3) into consideration. The Certain Trends (TC) will be presented according to the order in Figure 5.1.

TC1: Demand- The respondents describe the demand for ML-based tools as a trend having a large impact on its future usage within the public primary school. Further, the interviews bear witness of a perceived future strong and continuous increasing demand. This parallels with the theoretical findings which describes an increased demand and industrial focus on EdTech, AI and ML (Holon IQ, n.d; EdTech Sweden, 2016; Swedish National Agency for Education, 2017). Further, Lundin stress that the industry of AI is experiencing a current cycle of hype which aligns with the research of Reaktor (n.d.), describing that the field of AI has experienced several cycles of hypes which have previously ended with a decrease in interest, research efforts and investments. Further, recent advancements in technology strengthen Lundin's arguments of a current cycle of hype (Angarita, 2016). One might argue that a possible end to the described hype could hinder ML from becoming a future established part of the public primary school in Gothenburg. However, Lundin describes that this cycle differs from the previous due to the possibility of accessing large data sets. Moreover, Masiello highlights that one of the main reasons for the increased demand is that it has now become more coercive due to an increased interest by the authorities and recently employed regulations, contradicting a future end to the current hype. Further, a majority of the respondents believe that ML will have a large impact on the future of education.

***TC2: Time Perspective* -** Issues related to a short-term focus was described by several of the respondents, indicating that many products offer halfway solutions with short-term profits, lacking support and after-services. The majority of the respondents who mentioned issues related to the short-term time perspective are from the groups Education and Politics. Additionally, the two respondents from the group Expertise mentioning the factor are researchers from academia and not company representatives. This might argue for a conflict of interest between the demand and supply side, as the the companies seem to be somewhat unaware of this critique. Due to the evident clash between demand and supply, companies on the market might arguably benefit from offering more long-term solutions based on profound industrial knowledge. As stated by EdTech Sweden (2016), a more long-term perspective could be obtained by increased knowledge. Further EdTech Sweden (2016) states that clearer regulations would help support a more long-term focus. This parallels the opinion of Masiello, who mentions the unclarity of how to employ governmental strategies such as e.g. the Digiplan, indicating that regulations have a large impact on the future usage of ML within the public primary school.

TC3: Combined Usage- Many of the respondents agree on the benefits of using ML-based tools as a complement to traditional teaching methods, also highlighting the need for social interaction and guidance by human teachers. This parallels research stressing that the pace and magnitude of replacing human jobs with robots is less than what is often expected (Nedelkoska & Quintini, 2018). According to Nedelkoska and Quintini (2018), digitalizing the educational field should not result in the replacement of human jobs due to the need for a high level of social relationships and human elements. Because of an expected increased involvement of digital tools and ML within the educational field (Holon IQ n.d; EdTech Sweden, 2016; Swedish National Agency for Education, 2017) and the continued importance of the teacher, one might argue for an expected future combined usage of the teacher and digital tools. However, Stigert spoke in favor of excluding digital tools from the primary school, believing it to be more suitable in later educational stages.

TC4: Adaptive Learning- The usage of digital tools to make the teaching more adaptive was described as the future of Swedish education by many of the respondents. According to Kristoffersson, ML-based tools have the potential to enhance adaptive learning. Research parallels this view, stating that adaptive learning equals improved learning (Liu, McKelroy, Corliss

& Carrigan, 2017). However, despite many of the respondents stating that adaptive learning might lead to improved educational results, Anonymous stresses that ML is beneficial but not necessarily required to reach the desired end-state of adaptivity. Further, adaptation was also considered being related to possible negative outcomes. Stigert, for example, believes that the Swedish school's deteriorated results are partially due to an increased individualistic mindset. However, he stresses that a certain type of adaptation could be beneficial. Lindblad agrees, describing the need to empower the group. The fact that undeveloped tools, produced to provide adaptive learning, are available on the market (Liu, McKelroy, Corliss & Carrigan, 2017) might negatively impact the students' learning outcomes. This indicates the need for more research and improved technology for the school system to enjoy the potential benefits from a more adaptive way of teaching.

TC5: Teacher's Role- The teacher's role is considered being continuously important, even in a future potentially more digitized school environment. Research from Holon IQ (n.d) parallels this view, highlighting the importance of human interaction and pedagogical environment between teachers and students. Further, the empirical investigation describes the teacher's autonomy when choosing which materials to include in the teaching. The described autonomy arguably indicates that the teachers' attitudes and interest in digital tools have a large impact on the future shaping of the Swedish primary education. This aligns with Holon IQ (n.d), highlighting the teachers' importance for an increased usage of ML. Therefore, the teachers of today need to gain increased knowledge and skills regarding a digital future (Holon IQ, n.d). In addition, several respondents highlighted a future possible change in the teacher's role, stating that ML might enable the teachers to focus more on the actual teaching, decreasing their focus on administrative tasks. Further, Holon IQ (n.d), states that the administrative tasks rather than the educational will be automated in the near future. Contradicting this view however, is the current increased supply of ML-based tools developed for teaching materials. According to EdTech Sweden (2016), the largest future growth of EdTech-related products is expected within the market segment of teaching materials.

TC6: Shortages and Vagueness- The respondents describe shortages related to ML being connected both to the large amount of data necessary for the technology to work and to aspects such as cultural bias. Reaktor (n.d.) highlights similar implications. According to Bughin et al. (2017), the increased focus on AI has partly been supported by the access to larger amounts of data. However, Lundin highlights that the war of data will continue to play an essential role as people are beginning to understand the value of their personal data. In addition, regulations are described as limiting the usage of digital tools since available products are not adapted to the regulations. In order for ML to become more widely adopted in the public primary school, companies would benefit from constantly updating their products so that they are compatible with current regulations and strategies. Cultural bias will continue to be a shortness since the data will continue to be produced by humans. Lastly, another shortage described by the respondents is related to the complexity of the ML technology. As mentioned by Masiello, users describe ML-based tools as complicated, wherefore he suggests the companies to increase their focus on enhancing the tools' pedagogical benefits instead of their current technical advancements as it would be more comprehensible. These statements suggest that the users are in need for increased knowledge regarding the usage of ML tools. According to Royal Society (2017), the definition of AI cannot be considered fixed. Lundin stresses that the vague definition might result in the creation of a misleading image of the greatness of ML. The vague definition might therefore become a factor impacting the future usage of ML if it does not fulfill its expectations.

TC7: Inertia- The slow and inert processes connected to the public primary schools in Gothenburg are considered to have a great future impact of the implementation process of the ML-based tools in the industry. This parallels with EdTech Sweden (2016), arguing for the digitalization of the Swedish school system to be inert due to the slow processes and deficient political governance. In addition to the regulatory inertia, Vinnova (2018), highlights the difficulties of implementing ML-based tools in the public sector. Further, Heintz believes the industry to be inert due to a lack of valuable knowledge and research which is confirmed by Vinnova (2018), stating that the public sector has the lowest knowledge of how to use the technology of ML. However, as argued by several respondents, the public-sector benefits from a certain degree of inertia, leading to a trade-off between making too rapid decisions and discouraging an industrial innovation process, as argued by Masiello and Lundin.

TC8: Attitudes- All respondents claim that the usage of digital tools is established in the Swedish school system, although many inequalities between the schools exists. The respondents in the Education group consider that the effort to offer one computer per child is successful and prefer large-scale investments as opposed to short-term solutions. However, many believe that later classes should be prioritized when regarding a digital usage. Despite the positive attitudes towards including digital tools, the usage of ML-based tools is currently almost non-existing. One potential explanation for the lacking usage might be to the security aspect described by Holon IQ (n.d) since data is sensitive and dependent upon proper authentication and verification. Moreover, the actors in the EdTech industry desire knowledge of how companies use the data, something that cannot be secured at this early stage, arguing for a limited usage of ML techniques (Woolf et al., 2013). However, several of the respondents, argue that the administrative tasks will be favored by a usage of ML as opposed to the learning (Holon IQ, n.d). In addition, increased administrative usage might have the possibility to enhance the trust and interest of ML technology, arguing for a more widespread future usage.

Uncertain Trend (TU) Analysis

In the following paragraphs, the 3 identified Uncertain Trends (TU) will be further analyzed, taking both the empirical findings (chapter 5) and the theoretical framework (chapter 4) into consideration. All Uncertain Trends (TU) are followed by two extreme outcomes related to the future of each uncertainty.

TU1: Technical Infrastructure- According to the respondents, a lack of an appropriate technical infrastructure makes it difficult or even impossible to increase educational digitization, highlighting technical infrastructure as a critical uncertainty when regarding the future role of ML-based tools. The Swedish Association of Local Authorities and Regions (2018) argues that Sweden should be one of the world leading actors within EdTech by 2022, a goal considered difficult reaching with the current poor technological infrastructure. This aligns with the statements presented by Stigert, arguing that the lack of technical infrastructure is the biggest hurdle for implementing technical solutions. Moreover, the lack of technical infrastructure enhances inequalities between schools in Gothenburg (Gothenburg City, n.d) which is further highlighted by Student Grade 9 who is experiencing inequalities between the schools in terms of digital usage. Further, EdTech Sweden (2016) argues tremendous investments in technology to be a solution for inequalities. Another aspect is that the tools developed by the companies possess high quality, while the schools lack technical infrastructure. Therefore, the technology in the schools is not mature enough to use the current available tools (Holon IQ, n.d). This is further highlighted as a critical hurdle to overcome according to the interviewed company representatives.

Outcome 1: The technical infrastructure supports a widespread usage of ML-based tools within the public primary school in the city of Gothenburg.

Outcome 2: The technical infrastructure does not support a widespread usage of ML-based tools within the public primary school in the city of Gothenburg.

TU2: Knowledge and Research- The demand for research and proven results regarding the effects of using ML-based tools is considered high in the Education group, enabling a more effective employment of the technologies. Moreover, the companies interviewed face problems to educate the users about their products, arguing for problems with diffusion of digital tools due to a knowledge gap between the demand and supply side. According to Masiello, this is considered being an industrial challenge since educating the users is time-demanding and currently not prioritized due to the need to solve other more urgent challenges, such as the shortage of teachers. Heintz argues for a lack of national competence being a fundamental reason for why the education sector is inert. Some existing research is currently commending the future effects of increased digitization and usage of ML. However, since the demand side both requires concrete evidence about the usage of specific tools and are skeptical towards new tools, this research does not decrease the knowledge gap. Additionally, EdTech Sweden argues that improved research and knowledge is important to increase the future adoption rate of e.g. ML. Woolf and Kolodner (2013) believe research and knowledge to be important factors to inform users when digital or analogue tools are preferred. Therefore, the increased focus on common incentives such as e.g. the Digiplan introduced by SKL, will hopefully increase the knowledge and strengthen the discussion about further usage of digital tools. According to Government Offices of Sweden (2017), increased knowledge and research is further dependent upon knowledge sharing between the different actors within the industry, where integration of the different stakeholders and their expertise will create a broad knowledge base that might lead to a more developed industry.

Outcome 1: Research and proven results regarding the effects and most beneficial ways of using ML-based tools are available and easy to understand.

Outcome 2: Research and proven results regarding the effects and most beneficial ways of using ML-based tools are limited and difficult to understand.

TU3: Regulations- According to Holon IQ (n.d), regulations struggle to keep up with security aspects due to slow processes connected to the public sector and a rapid digital development. Despite recent changes, e.g. the new curriculum, several respondents describe that the regulatory incentives are continuously lacking. In addition, the changes are described as being difficult to implement and adapt to, due to the inert and conservative nature of the sector. Moreover, the incentives are often short-term and result in personal interpretations, wherefore the national strategies need to be more precise and clear to avoid misunderstandings. It is further important to address how tools should be used, as opposed to solely describing the desired end-state of a more digitized school without providing any guidance. Accordingly, the government should work more effectively with becoming transparent and address the current challenges in the industry (EdTech Sweden, 2016). However, it also considered being a structural problem, where the most effective solution is to reform the school system more profoundly in order for the digital tools to be fully established and used on a daily basis (Government Offices of Sweden, 2017).

Outcome 1: The regulations are supportive, clear and explicitly describe how to perform the determined national digitalization strategies, elucidating how to approach critical areas.

Outcome 2: The regulations are unsupportive, unclear and vague, solely describing the aim to digitalize the public primary school.

Uncertainty Correlation Matrix

A Correlation Matrix has been used to investigate the possible relationship between the identified Uncertain Trends (TU). To develop the future scenarios, this step is important since all combinations of the Uncertain Trends (TU) may not possibly occur simultaneously. To visualize the interrelationships between the the uncertainties, a positive correlation (+) indicates that the the chance of Outcome 1 for uncertainty X to occur would increase the chance of occurrence for Outcome 1 for uncertainty Y. A negative correlation (-) however, occurs if the chance of occurrence goes down. Further, no correlation (0) and undetermined correlation (?) are two additional possible outcomes. The Correlation Matrix is described more in detail in section 3.3.2. Moreover, to investigate the internal reliability, a Cronbach's Alpha analysis has been conducted (see Appendix 4) with a result of α=0.729, indicating internal reliability since 0,729 >0.7, as suggested by Bryman and Bell (2015). Below follows a presentation of the correlation of all Uncertain Trends (TU), analyzed with Pearson's r (see Appendix 3). As visualized in the Correlation Matrix, all three Uncertain Trends (TU) have a positive correlation (see Figure 5.5).

Correlation Matrix			
	TU1	**TU2**	**TU3**
TU1		+	+
TU2			+
TU3			

Figure 5.5 Correlation Matrix of Uncertain Trends (TU)

+ TU1 Technical Infrastructure and TU2 Knowledge and Research- According to the performed Pearson's r analysis the uncertainties TU1 and TU2 have a positive correlation of 0.341 (see Appendix 3, Attachment 1). Further, as stated in the empirical data, increased knowledge regarding the benefits of using ML would arguably work as an incentive for improved infrastructure. Kristoffersson stresses that more research regarding the rapid ML development is crucial since it would decrease the uncertainties currently connected to the technology. Therefore, one might argue that more research and proven results would potentially decrease the aforementioned uncertainties and motivate improvements regarding the technical infrastructure.

+ TU1 Technical Infrastructure and TU3 Regulations- According to the performed Pearson's r analysis the uncertainties TU1 and TU3 have a positive correlation of 0.38 (see Appendix 3, Attachment 2). In addition to the quantitative analysis, Masiello argues regulations to be used as coercive means for the schools' digital adoption. Therefore, clearer and more explicit regulations are expected to have an impact on technical infrastructure, resulting in a more widespread usage. On the contrary, Heintz describes the current regulations as vague and open for misunderstandings, why the future political incentives need to be clear and explicitly describe how to perform the determined national digitalization strategies in order for the regulations to have a direct impact on the technical infrastructure.

+TU2 Knowledge and Research and TU3 Regulations- According to the performed Pearson's r analysis the uncertainties TU2 Knowledge and TU3 Regulations have a positive correlation of 0.864 (see Appendix 3, Attachment 3). Previously employed regulations, e.g. the new curriculum, have impacted the usage of digital tools in the public primary school, e.g. by including programming. This in turn might have affected the availability of research and proven results regarding the subject. However, even if regulations can lead to improved knowledge and research, there is still a demand for improvements. As for example, Lindblad continues to demand research and proven results regarding the effects and most beneficial ways of using ML, despite the increased digital regulatory focus.

Impact and Uncertainty Grid Summary

To conclude the analysis, 11 trends were identified as factors that will play a large part on the future role of ML. Further, a Perception Analysis was presented, resulting in eight Certain Trends (TC) and three Uncertain Trends (TU). Additionally, the analysis indicated that the future outcome of all uncertainties (TU1-TU3) will impact the Certain Trends (TC) differently, and thus impact the role of ML within the future educational sector. Moreover, the uncertainty Correlation Matrix showed that all three identified uncertainties (TU1-TU3) correlate, i.e. that all combinations of the three uncertainties may occur simultaneously in a future scenario. In the following section, the Certain Trends (TC) and the Uncertain Trends (TU) will be used to develop four scenarios, aiming to answer the research question regarding the role of ML in the future of the public primary school in Gothenburg within a five-year period.

5.2 Step 4: Scenario Development

Extreme Values and Scenario Outline

A first step in determining the future scenarios, is to develop extreme values that will constitute the axes in the Scenario Matrix which is consisting of four quadrants (see Figure 5.6). The selection of extreme values was based on three criteria (see Figure 3.8). Having the criteria in mind, the combinations of Technical Infrastructure (TU1) and Knowledge and Research (TU2) and Knowledge and Research (TU2) and Regulations (TU3) both have the highest jointly perceived level of influence and uncertainty of 24.1, ((6.1+5.3) + (7.1+5.6)) and ((7.1+5.6) + (6.2+5.2)) (see Table 5.2 and Table 5.3). However, due to the combination of TU1 and TU2 having the highest number of mentioning and a positive correlation, the uncertainties forming the extreme values will be Technical Infrastructure (TU1) and Knowledge and Research (TU2). Based on the extreme values of TU1 and TU2, the values on the axes will be based on the two outcomes of TU1 and TU2 respectively, namely, Availability of Research and Proven Results, Lack of Research and Proven Results, Supportive and Widespread Technical Infrastructure and Unsupportive and Narrow Technical Infrastructure (see Figure 5.6). The scenarios are presented as narrative stories and are further elaborated on in the following sections.

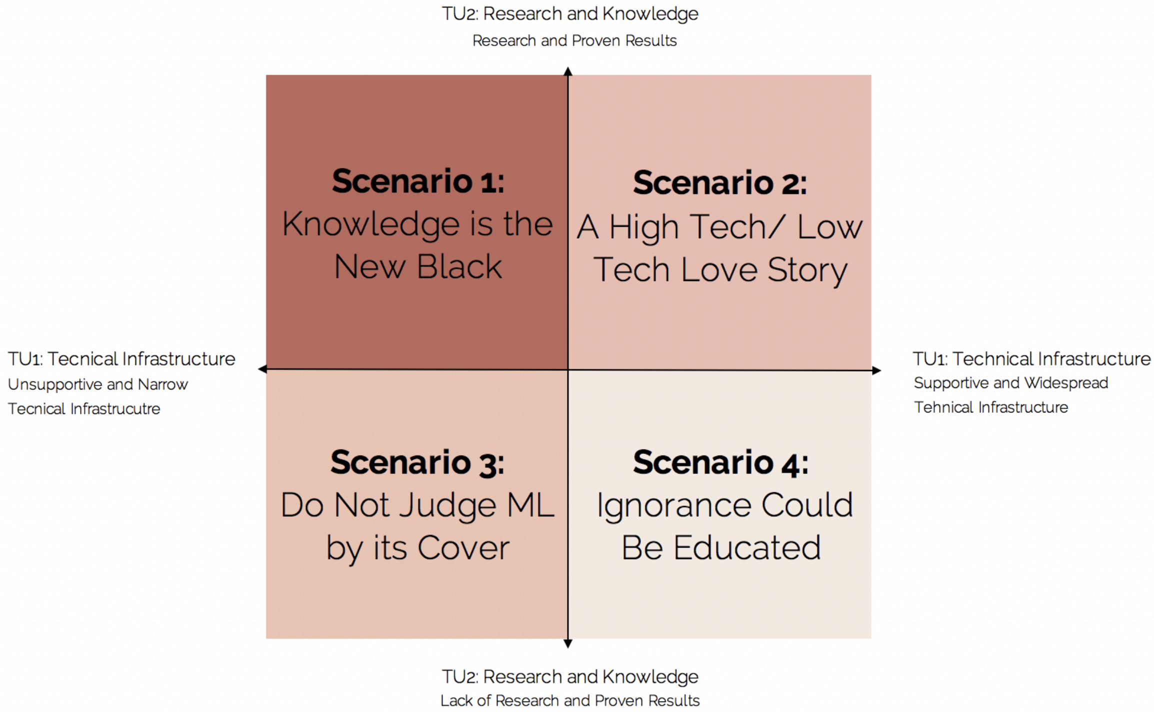

Figure 5.6 Scenario Matrix Visualizing the Four Scenarios

Scenario Storylines

In the following section, four scenarios will be presented, all mapping the future role of ML in the public primary school in Gothenburg. The scenarios include all previously identified Certain Trends (TC) and Uncertain Trends (TU) as they will have a great impact on the future of the industry. Due to the five-year time horizon of the research, these scenarios should be read from the perspective of the year 2024. To provide clarity, storylines and Influence Diagrams have been developed, making the narratives easier to understand. Lastly, to create gender neutral scenarios, hir will be used instead of her/his and s/he will be used instead of she/he in all scenarios. The four scenarios will be presented below on the following pages.

Scenario 1: Knowledge is the New Black

A teacher enters the classroom, about to begin the first lecture of the day. According to recent studies, using digital tools is favorable in certain subjects, why s/he teaches the lecture analogously. Everything flows frictionless. In the next lecture however, all students use their own computers. Suddenly, a student experience technical problems, taking unnecessary time from the teacher. S/he has red plenty of reports discussing the outcomes of using ML-based tools in school. Obviously, ML-based tools would not work in hir school because of the lacking Wi-Fi. The frustration makes hir reject the offer s/he got this morning regarding the testing of a new high-tech ML robot. How would the robot possibly work if not even the day-to-day tasks do?

In scenario one, the technical infrastructure does not support a widespread usage of ML-based tools within the public primary school in Gothenburg within a five-year period. However, research and proven results regarding the effects and most beneficial ways of using ML-based tools are available and easy to understand. Therefore, the regulations are not supportive, why an inertia is still present within the industry. Moreover, due to the unsupportive and narrow infrastructure, the usage of ML is continuously conspicuous by its absence. In addition, the deficient infrastructure is preventing the usage of ML from increasing and continues to function as a barrier for the equality amongst the schools in Gothenburg. However, as highlighted in Figure 5.7, the main driving factor characterizing the scenario is the supportive research and knowledge. Following the increased amount of research and proven results, the outcomes of using ML in general and how teachers should handle specific ML-based tools in particular has decreased former shortages and vagueness related to the technology (see Figure 5.7). Principals and teachers now have a broader understanding of the technology, resulting in more knowledge-based decisions regarding what and how to include/exclude ML tools in/from their daily work. Further, the increased knowledge impacts the current supply, forcing companies to develop more long-term products based on an enhanced awareness regarding the actual demands and needs of the public primary school, as demonstrated in Figure 5.7. The current knowledge and unsupportive and narrow infrastructure further impacts the demand, where the proven results influence the usage of ML and whether the technology is included/excluded in/from the educational sector. Further, the proven results have not impacted the role of the teacher, which continues to be a crucial asset. The administrative tasks will not have the opportunity to be streamlined by ML and structural problems such as the lack of teachers, continues to be a problem which will not be solved by ML

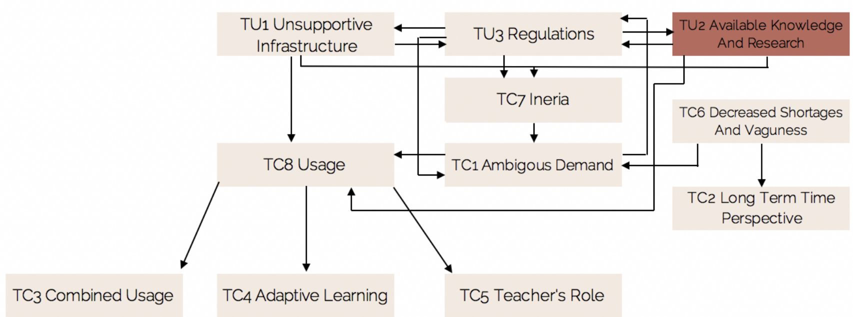

Figure 5.7 Influence Diagram Scenario 1

Scenario 2: A High Tech/Low Tech Love Story

A teacher enters the classroom, about to begin the first lecture of the day. The teacher has just read a report presenting research regarding the usage of ML-based tools. This has made hir reflect upon what s/he should respond to the offer of investing in an ML-based teaching tool. S/he recently realized that some of the appreciated administrative tools are based on the ML technology, making hir wonder if it would be possible to include ML in the teaching as the Wi-Fi is currently working frictionlessly. Suddenly, the teacher's thoughts are interrupted by the first student entering the classroom. The lecture commences collectively and precedes with personally adapted assignments. The usage of adaptive learning makes the teacher wonder: Could ML be the answer to a future of even more adaptive way of teaching?

In scenario two, the technical infrastructure supports a widespread usage of ML within the public primary school in Gothenburg while research and proven results regarding the effects and most beneficial ways of using ML-based tools are available and easy to understand, leading to these two factors being important drivers in the scenario (see Figure 5.8). As a consequence, the regulations are therefore more supportive, leading to decreasing industrial inertia. However, due to the public nature of the sector, the processes are continuously somewhat inert. As a consequence of the improved infrastructure and increased knowledge and research, potential for increased usage and demand exists. Yet, the potential of an increased demand is restricted and dependent on the outcome of current research. However, the demand side is more conscious about their decisions regarding what tools to buy and use, because of decreased vagueness regarding the most beneficial ways of using ML. Therefore, the narrow existing usage of ML tools is implemented with a long term focus based on improved knowledge (see Figure 5.8). The ML-based tools are part of an ecosystem where teachers, students and principals all work together for an effective implementation of the tools. Nevertheless, a technological skepticism is still existing despite supportive infrastructure and increased knowledge, wherefore the implementation rate is still low. However, increased knowledge regarding when ML-based tools are beneficial to use enables incentives for a future more widespread usage. Moreover, the teacher's role is still important and due to the increased knowledge, the potential to combine digital and analogue tools has improved, enabling adaptive learning (see Figure 5.8). Further, many ML-based tools are available. In addition, tools decreasing the administrative tasks, previously considered as time consuming now have the potential to become more streamlined by ML

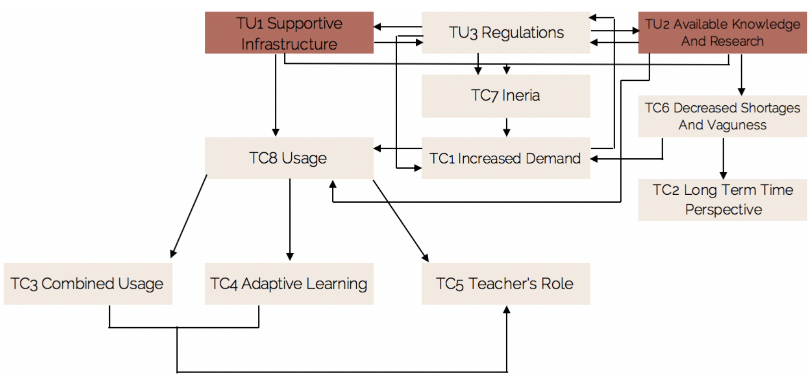

Figure 5.8 Influence Diagram Scenario 2

Scenario 3 Do Not Judge ML by its Cover

A teacher enters the classroom, about to begin the first lecture of the day. S/he was recently offered an ML based teaching tool. However, s/he does not know much about ML and has not heard about anyone using it. S/he believes that ML sounds complicated, but the seller made it sound as a necessity and s/he feels pressured to accept the offer. It sounded cool! When the ML tool arrives, the teacher does not know how to install it and when the installation finally works, the internet is non-functioning. The teacher is tired of the lacking technical infrastructure and immediately regrets the ML investment, s/he does not even know how to use it. In despair s/he ponders: How do I know which digital tools to use? I wish there was a product that would enable me to focus more on the teaching than on administrative tasks!

In scenario three, the research and proven results regarding the effects and most beneficial ways of using ML-based tools are limited and difficult to understand and the technical infrastructure does not support a widespread usage of ML within the public primary school in the city of Gothenburg. Therefore, these factors do not act as driving factors as opposed to the other scenarios (see Figure 5.9). As a consequence, the industry is stuck in old patterns without research proving the effects of including ML, arguing for no incentives to improve the infrastructure. This in turn affects the demand which is persistently relatively low since the teachers and principals are skeptical towards additional ML tools due to the lack of knowledge and research about their long-term effects. Due to the lack of knowledge and infrastructure, the suppliers continue to produce tools with a short-term focus and the investments in ML, if any, are not based on information (see Figure 5.9). Some schools try to implement ML tools, but the efforts are limited if not non-existing. The usage of ML is depended upon own interest, partly due to unsupportive and vague regulations solely describing the aim to digitize the school, without elucidating how to approach critical areas. Due to the lack of guidance, the usage is limited since the teachers do not know when it is favorable to use ML-based tools and instead of e.g. analogue teaching (see Figure 5.9). Therefore, the users do not understand how they create value, arguing for an ineffective usage. Further, the teacher faces tribulations since understanding the motives for using ML and its complicated technology is ineffective and time-consuming. However, the teacher's role is being continuously important, even if the lacking infrastructure and knowledge does not support an altered role. Lastly, the past cycle of hype regarding ML has potentially begun to fade due to uncertainties and a decrease in interest, research efforts and investments.

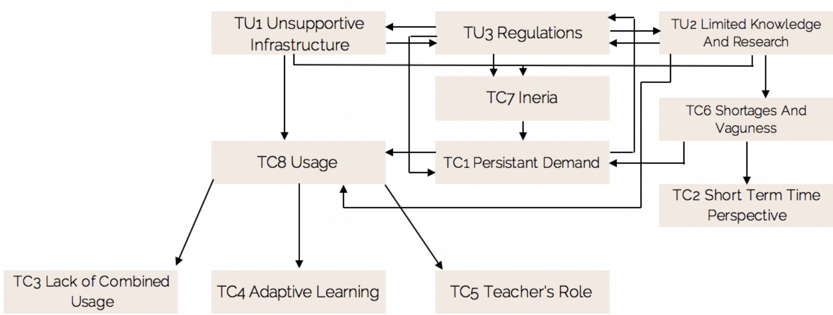

Figure 5.9 Influence Diagram Scenario 3

Scenario 4: Ignorance Could be Educated

A teacher enters the classroom, about to begin the first lecture of the day. S/he is happy since the school's new Wi-Fi is faster than ever. Recently, the teacher attended a meeting with a company providing high-tech ML-based tools. The company offered a free trial which the teacher will undertake, albeit having deficient knowledge. Nevertheless, when starting the trial, the teacher becomes worried. Will machines based on ML replace hir in the future? When the trial ends, the teacher doubts the tool's outcomes as s/he cannot strengthen it with any proven research. S/he does not want to risk using unsecure tools when teaching. However: Could the ML technology possibly be favorable in streamlining the time-demanding administrative tasks until its possible beneficial outcomes are proven? Would be a pity not to take advantage of the new Wi-Fi.

In scenario four, the technical infrastructure supports a widespread usage of ML within the public primary school in the city of Gothenburg while research and proven results regarding the effects and most beneficial ways of using ML based tools are limited and difficult to understand. The current regulations are more supportive, having improved the infrastructure. The infrastructure supporting a widespread usage of ML enables an increased demand for ML and due to a continued hype of the technology, new companies continue to enter the market, offering high-tech products. Moreover, the industrial inertia has been decreasing due to an increased supply but is still supported by the lack of industrial knowledge. However, the actors consider the inertia to be appropriate to secure the quality within the industry. Further, the lack of knowledge results in a continuous short-term company focus when developing their products as demonstrated in Figure 5.10. Due to the lack of research, shortages and vagueness related to the technology are still existing. However, despite the schools' existing level of skepticism, some continue to make incautious investments based on the high expectations of ML. Following the infrastructure supporting a widespread usage of ML, the combined usage of traditional and ML-based tools has increased. Further, ML is considered being a potential tool to achieve adaptive learning. However, combined usage does not affect the adaptive learning as in Scenario 2, due to the limited knowledge and research regarding the effects of ML (see Figure 5.10). Therefore, Teachers continue to worry about their future role despite the experts being certain of their importance. However, due to a lack of knowledge, the principals and teachers continue to be unaware of how to use ML in the most beneficial way and how to respond to the industrial changes.

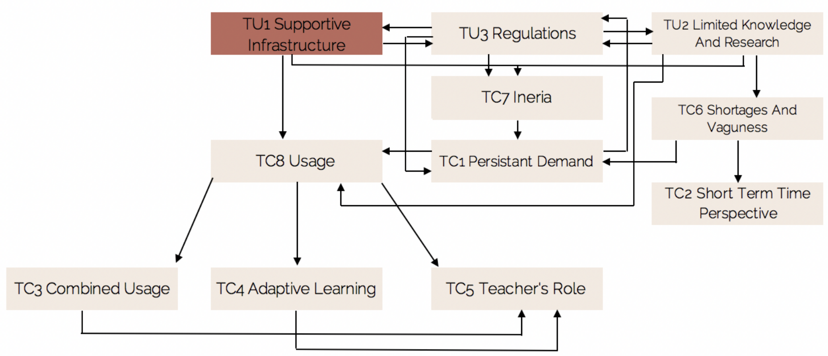

Figure 5.10 Influence Diagram Scenario 4

6. Conclusion and Future Research

In the following chapter, Step 5 in the customized Scenario Planning model will be presented, namely, Scenario Learnings and Future Research. These two sections aim to present the conclusions of the research and answer the research questions. Firstly, the scenario learnings will be presented, with concluding comments and a short summary of the four scenarios. Thereafter, the researchers' suggestions for future research will be presented.

6.1 Step 5: Scenario Learnings and Future Research

Scenario Learnings

The initial research question to be answered in the study is: *'What is the role of Machine Learning in the future of the public primary school in Gothenburg within a five-year period?'* To properly answer the research question, two sub-questions were assigned, being: *'What trends are identified to impact the future role of Machine Learning in the public primary school in Gothenburg?'* and *'What uncertainties are identified to impact the future role of Machine Learning in the public primary school in Gothenburg?'* . During the study, the researchers found 11 trends, impacting the future role of ML in the public primary school in Gothenburg, namely, Demand, Time Perspective, Combined Usage, Adaptive Learning, Teacher's Role, Shortages and Vagueness, Inertia, Usage, Technical Infrastructure, Knowledge and Research and Regulations. Three out of the 11 trends were defined as Uncertain Trends (TU), being, Technical Infrastructure, Knowledge and Research and Regulations due to a Perception Analysis where respondents expressed the trends' perceived level of impact and uncertainty. The certain and uncertain trends constitute the foundation for the scenario development and hence, describe the future role of ML in the public primary school in Gothenburg in a five-year period. Based on the Perception Analysis, interviews and Correlation Matrix, Technical Infrastructure (TU1) and Knowledge and Research (TU2) were appointed as extreme values, functioning as a basis for the four developed scenarios. Below follows concluding comments regarding the developed scenarios.

Scenario 1: Knowledge is the New Black- In scenario one, the technical infrastructure does not support a widespread usage of ML within the public primary school in the city of Gothenburg. However, research and proven results regarding the effects and most beneficial ways of using ML based tools are available and comprehensible. The unsupportive and narrow infrastructure leads to an absent usage of ML. Following the increased amount of research and proven results, the shortages and vagueness related to the technology have decreased, actors make more knowledge-based decisions and the increased knowledge impacts the supply, forcing companies to develop more long-term solutions.

Scenario 2: A High Tech/Low Tech Love Story- In scenario two, the technical infrastructure supports a widespread usage of ML within the public primary school in the city of Gothenburg while research and proven results regarding the effects and most beneficial ways of using ML tools are available and comprehensible. As a consequence, the potential for an increased usage and demand exists. However, the usage of ML-based tools is currently limited. Further, the shortages and vagueness related to the technology have decreased, resulting in actors making more knowledge-based decisions. The increased knowledge impacts the supply, making companies develop more long-term solutions. The teacher's role is still important and due to the increased knowledge, the potential of combining digital and analogue tools has improved.

Scenario 3: Do Not Judge ML by its Cover- In scenario three, research and proven results regarding the effects and most beneficial ways of using ML-based tools are limited and difficult to understand and the technical infrastructure does not support a widespread usage of ML-based tools within the public primary school in the city of Gothenburg within a five-year period. Consequently, the demand is persistent due to a lack of knowledge, enhancing the vagueness of ML-based tools and their potential benefits. Further, the investments in ML, if any, are unconscious and not based on information. Lastly, the past hype regarding ML has potentially begun to fade due to uncertainties and a decrease in interest, research efforts and investments.

Scenario 4: Ignorance Could be Educated- In scenario four, the technical infrastructure supports a widespread usage of ML within the public primary school in the city of Gothenburg while research and proven results regarding the effects and most beneficial ways of using ML-based tools are limited and difficult to understand. The infrastructure enables an increased demand for ML and due to a technological hype, new companies continue to enter the market. However, the companies have a short-term focus and shortages and vagueness related to the technology are still existing. Therefore, the principals and teachers continue to be unaware of how to use ML in the most beneficial way and how to respond to the industrial changes.

Based on the four developed scenarios including the 11 identified trends, the researchers show the future role of ML in the public primary school in Gothenburg in 2024, and the effects of the two Uncertain Trends (TU) Technological Infrastructure and Knowledge and Research. However, due to the uncertain and volatile world of today, one cannot predict how the uncertainties will develop wherefore all four scenarios are equally likely to occur within a five-year period. However, as confirmed by the majority of the respondents, ML does not have the potential to be widespread, albeit even used at all, within a five-year period due to the complexity of the technology as well as the inertia in the public primary school sector in Gothenburg. Additionally, the future usage of ML is strictly dependent upon a supportive technical infrastructure. Despite Sweden being in the forefront of digitalization, fundamental problems related to Wi-Fi and basic technical knowledge still exists within the educational sector. This further argues for the extensive knowledge gap currently existing between the companies and the users, where companies due to their profound knowledge offer high-tech products, too complicated for the schools to use due to the poor technological infrastructure. Therefore, an increased usage of ML is dependent on regulations considering such fundamental issues instead of focusing on a desired end state of a digitized educational sector. Scenario 2 and Scenario 4 demonstrate the importance of a supportive technical infrastructure to enhance the future role of ML while Scenario 1 and Scenario 3 indicate the importance of available research and proven results in order for the ML technology to be widespread within the public primary school in Gothenburg. Lastly, one can conclude that a widespread diffusion of ML will not occur within a five-year period, but possibly in a future, more long-term time horizon, potentially within the field of administration.

Future Research

The purpose of this research has been to investigate the future role of ML within the public primary school in Gothenburg. However, additional further research could enhance the knowledge of the researched areas. Firstly, the Scenario Planning method of the study is considered applicable to other industries and geographical areas. Therefore, and due to locally set governmental regulations, executing similar studies in other domestic or international regions would be of great interest. In addition, performing comparative studies comprising the educational sector in Gothenburg and other regions would be of interest, having this thesis as a basis for the study. Moreover, since many of the respondents in the study indicated a preferred digitization of education in higher classes, it would be interesting to conduct a study of the future usage of ML in higher educations, preferably at high school or at university level, to investigate a potentially more positive attitude towards the future role of ML. Lastly, the researchers concluded that the usage of ML will not be widespread in the public primary school within a five year period due to a lack in basic research and technical infrastructure. Therefore, investigating more fundamental parts of the school's digitalization process would be favorable as the current lack of technical infrastructure does not support any high-tech digital solutions. It might further provide the decision makers with information regarding areas in a crucial need for improvement.

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Appendix

Appendix 1: Interview Guides

Attachment 1: Interview Guide Expertise

Introduction

This interview is part of a Master's Thesis project in Innovation and Industrial Management. We are conducting a study regarding the role of Machine Learning in the future of education. The purpose of this research is to study the role of ML within the field of the public primary school in the Swedish city of Gothenburg in the coming five years. In doing so, the study will serve to give insight in how a future adoption of Machine Learning in the field of education might look like. By studying and combining these areas, concerned parties and companies might get a deeper understanding of the possibilities connected to the technology and the field of education.

Secrecy

- *All information will solely be used for the purpose of this study-*

1. Would it be OK for us to record the interview?
2. Do you wish to be anonymous?

Background

1. Tell us about your background
    - Title
    - Experience
    - How long have you been working at this company/in this profession?

2. Tell us about your company/profession
    - *Just for companies:* Which are your main customers?
        - Private schools?
        - Public schools?
        - Both?
        - Companies?
    - *For all:* How do you work with Machine Learning?

Machine Learning in Education

Past

1. How come you started working with Machine Learning within the field of education?

2. *Just for companies:* What type of tools do you provide?

3. Has the demand for ML within the field of education evolved/changed during the past five years?

- If yes: What do you thinks has led to that development?
- If yes: Where there any challenges?

Present

1. What are your thoughts on Machine Learning in general?

2. What are your thoughts on ML within the field of education?

- Positive aspects?
- Negative aspects?

3. What are the current areas of application of ML within the field of education?

4. Are there any other industries where ML is more widespread?

- Why?/Why not?

5. How is the market for ML in education?

- Competition?
- Saturation?
- How do schools use tools incorporating ML today?
    - Difference between universities and primary schools?
    - Difference between private and public schools?

6. Do you believe that the tools currently available is developed enough to be used in all schools? Is there a sufficient demand for these types of tools?

- Is there a gap between supply and demand?

7. What is your interpretation of the schools' current usage of digital tools based on ML?

- If lacking:
  - Why?
  - Why not?

8. What would increase the usage of digital tools based on ML in the Swedish public schools? (E.g. barriers like cost, knowledge, regulations, inertia?)

9. *For companies:* Which are your greatest challenges as company?

10. Which are the greatest challenges in the industry?

Future

1. Looking into the future, will the usage of ML within education change within a five-year period?

- If yes:
  - Do you see any possible trends?
  - Are there any challenges?
  - Uncertainties?
- If no:
  - Why not?

2. What are the future areas of application of ML within the field of education compared to today?

- Timeframe?
- What will be needed for a further development and diffusion of ML?

3. In a dream scenario, how will the field of education look like within a five-year period?

Additional

1. Do you have anything to add that we have not talked about during this interview?

Attachment 2: Interview Guide Education

Introduction

This interview is part of a Master's Thesis project in Innovation and Industrial Management. We are conducting a study regarding the role of Machine Learning in the future of education. The purpose of this research is to study the role of ML within the field of the public primary school in the Swedish city of Gothenburg in the coming five years. In doing so, the study will serve to give insight in how a future adoption of Machine Learning in the field of education might look like. By studying and combining these areas, concerned parties and companies might get a deeper understanding of the possibilities connected to the technology and the field of education.

Secrecy

- *All information will solely be used for the purpose of this study-*

1. Would it be OK for us to record the interview?
2. Do you wish to be anonymous?

Introduction to Machine Learning (if requested by the respondent)

In broad terms, the technology of AI is commonly described as the art of creating machines with the ability to think, make decisions, solve problems, learn and act in ways normally associated with humans. Machine Learning, which is the primary focus in this study, is a sub-group of AI. ML is a technology that studies data to learn how to perform a specific task without explicit instructions. The technology learns directly from examples and experiences in the data, from which it can identify meaningful patterns. In the field of education today, ML is primarily incorporated in digital tools to identify how an individual learns in order to adapt educational content and feedback to the individual.

For example, the technology has the ability to recognize the amount of pauses a student makes during a lesson, the number of times a question is answered incorrectly and the time needed to answer a question and adapt the learning based on the students' performances.

Background

1. Tell us about your background
    - Age*(if student: School and grade)*
    - Title
    - Experience
    - How long have you been at this school?

Machine Learning in Education

Past

1. Have you previously been using any digital tools at your school? E.g. computers and software
    - If yes:
        - o Why have you been using them?
        - o To what extent?
        - o What type of tools?
        - o How did you experience the tools?
    - If no:
        - o Why not?

2. Has your usage of digital tools evolved/changed during the past five years?
    - If yes:
        - o How?
        - o What led to that development?
        - o Were there any challenges in adapting to the usage?
    - If no:
        - o Why?

Present

1. What are your thoughts on digital tools in school?
    - Positive aspects?
    - Negative aspects?

2. Are you currently using any digital tools in school?

- Why/Why not?
- To what extent?

3. Do you know what ML is?

- If yes:
    - o How would you describe it?
- If no:
- The researchers explain with help of the introductory text

4. Have you ever tried a digital tool incorporating ML in your daily life?

- If yes:
    - o How did you perceive the tool?

5. Have you ever tried a digital tool incorporating ML in school? E.g. a tool which might recognize the amount of pauses a student makes during a lesson, the number of times a question is answered incorrectly and the time needed to answer a question and adapt the learning based on the students' performances.

- If yes:
    - o How did you perceive the tool?

6. Are you aware of which digital tools that are currently available?

- If yes:
    - o Would any of these tools benefit your teaching?

7. What do you think about including some of the following tools in the primary education? (Show pictures and movies)

- A data program helping the students with for example math problems by personal suggestions of the student's improvement areas
- A robot which can assist students in learning foreign languages by talking and explaining things to them
- A tool to analyze the students' abilities to read and write by studying their eye movement?

8. According to you, what is the ultimate way of learning/teaching?

9. *For teachers only:* What would increase the usage of digital tools in your school? (Cost, knowledge, regulations, inertia?)

10. Which are your greatest challenges as a teacher/principal/student?

- Do you believe that digital tools can solve these challenges?

11. To what extent can you influence the implementation and usage of digital tools?

Future

1. Looking into the future, will the usage of digital tools change within a five-year period?

- If yes:
    - o Are there any challenges?
    - o Uncertainties?

2. In a dream scenario, how will the education look like within a five-year period?

Additional

1. Do you have anything to add that we have not talked about during this interview?

Attachment 3: Interview Guide Politics

Introduction

This interview is part of a Master's Thesis project in Innovation and Industrial Management. We are conducting a study regarding the role of Machine Learning in the future of education. The purpose of this research is to study the role of ML within the field of the public primary school in the Swedish city of Gothenburg in the coming five years. In doing so, the study will serve to give insight in how a future adoption of Machine Learning in the field of education might look like. By studying and combining these areas, concerned parties and companies might get a deeper understanding of the possibilities connected to the technology and the field of education.

Secrecy

All information will solely be used for the purpose of this study

- Would it be OK for us to record the interview?
- Do you wish to be anonymous?

Introduction to Machine Learning (if requested by the respondent)

In broad terms, the technology of AI is commonly described as the art of creating machines with the ability to think, make decisions, solve problems, learn and act in ways normally associated with humans. Machine Learning, which is the primary focus in this study, is a sub-group of AI. ML is a technology that studies data to learn how to perform a specific task without explicit instructions. The technology learns directly from examples and experiences in the data, from which it can identify meaningful patterns. In the field of education today, ML is primarily incorporated in digital tools to identify how an individual learns in order to adapt educational content and feedback to the individual.

For example, the technology has the ability to recognize the amount of pauses a student makes during a lesson, the number of times a question is answered incorrectly and the time needed to answer a question and adapt the learning based on the students' performances.

Background

1. Tell us about your background
- Title
- Role

The Swedish School System

1. In general, how would you describe the decision making process regarding the digitalization of the Swedish school system?

2. In general, how does the implementation process of digital tools work?

3. Are there any criteria for when a digital tool can be implemented?
- Quality?
- Price?
- Scalability?
- Ease of use? (for the student and the teacher)

4. Is there a difference between the usage of digital tools amongst the different schools in Gothenburg?
- What decides which tools each school get?

5. To what extent can you influence the implementation and usage of digital tools?

Machine Learning in Education

Past

1. Have the regulations and decision making regarding digital tools within the field of education evolved during the past five years?

2. Has the usage of digital tools evolved/changed during the past five years?
- If yes:
    - How?
    - What led to that development?
    - Where there any challenges in adapting to the usage?

- If no:
    - o Why?

3. Do you believe that the development has been rapid or inert?
    - Why?/Why not?

Present

1. What are your thoughts on digital tools within the field of education?
    - Positive aspects?
    - Negative aspects?

2. Do you believe that the primary schools in Gothenburg would benefit from an increased usage of digital tools?
    - If yes, which tools?
    - Which criteria do you consider being crucial for a digital tool to be classified as effective?

3. What would increase the usage of digital tools in the schools in Gothenburg? (Cost, knowledge, regulations, inertia?)

4. What are your thoughts on digital tools based on AI and Machine Learning in particular?
    - Positive aspects?
    - Negative aspects?

5. Do you have an insight in which digital tools that are currently available and used within the field of education?
    - Would you say that knowledge about available tools has an impact on your decision making?

6. How do you perceive the demand for digital tools in general and Machine Learning in particular? Has it increased during the last five years?
    - Students
    - Teachers

7. Do you believe that the available tools incorporating ML are developed enough to be used in a large scale? Is there a sufficient demand for these types of tools?

- Is there a gap between supply and demand?

8. Having digitalization in mind: Which are the greatest challenges for a teacher/principal/ student today?
   - Do you believe that digital tools can solve these challenges?

9. Which are your greatest challenges as a politician working with digitalization and innovation?

Future

1. Looking into the future, will the usage of digital tools change within a five-year period?
   - If yes:
     - Are there any political challenges?
     - Uncertainties?

2. In a dream scenario, how will the education look like within a five-year period?

Additional

1. Do you have anything to add that we have not talked about during this interview?

Appendix 2: Second Round Questionnaire in Swedish

Second Round Questionnaire

1. Sett ur ett femårsperspektiv: Hur stor påverkan tror du att följande faktorer kommer att ha på digitaliseringen av framtidens grunskoleutbildning? (1= Mycket liten påverkan- 10=Mycket stor påverkan)

	1	2	3	4	5	6	7	8	9	10
Ökad efterfrågan										
Kvaliteten på existerande digitala verktyg										
Teknisk infrastruktur- Exempelvis bristfällig internetuppkoppling										
Möjligheten till kombinerat användande- Digitala vertyg med lärarledda lektioner										
Kunskap och forskning										
Regelverk										
Möjligheten till anpassad inlärning										
Vikten av lärarens roll										
Brister och otydligheter kring digitala verktygs användande										
Långsamma processer										
Generell inställning till digitala verktyg										

2. Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert)

	1	2	3	4	5	6	7	8	9	10
Ökad efterfrågan										
Kvaliteten på existerande digitala verktyg										
Teknisk infrastruktur- Exempelvis bristfällig internetuppkoppling										
Möjligheten till kombinerat användande- Digitala vertyg med lärarledda lektioner										
Kunskap och forskning										
Regelverk										
Möjligheten till anpassad inlärning										
Vikten av lärarens roll										
Brister och otydligheter kring digitala verktygs användande										
Långsamma processer										
Generell inställning till digitala verktyg										

Appendix 3: Correlation Analysis SPSS

Attachment 1: Correlation between Variable TU1 Technical Infrastructure and TU2 Knowledge and Research

Correlations

		Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Teknisk infrastruktur - Exempelvis bristfällig internetuppkoppling	Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Kunskap och forskning
Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert):Teknisk infrastruktur- Exempelvis bristfällig internetuppkoppling	Pearson Correlation	1	.341
	Sig. (2-tailed)		.370
	N	9	9
Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Kunskap och forskning	Pearson Correlation	.341	1
	Sig. (2-tailed)	.370	
	N	9	9

Attachment 2: Correlation between Variable TU1 Technical Infrastructure and TU3 Regulations

Correlations

		Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Teknisk infrastruktur - Exempelvis bristfällig internetuppkoppling	Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Regelverk
Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert):Teknisk infrastruktur- Exempelvis bristfällig internetuppkoppling	Pearson Correlation	1	.380
	Sig. (2-tailed)		.314
	N	9	9
Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Regelverk	Pearson Correlation	.380	1
	Sig. (2-tailed)	.314	
	N	9	9

Attachment 3: Correlation between Variable TU2 Knowledge and Research and TU3 Regulations

Correlations

		Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Regelverk	Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Kunskap och forskning
Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Regelverk	Pearson Correlation	1	.864**
	Sig. (2-tailed)		.003
	N	9	9
Sett ur ett femårsperspektiv: Hur osäkra upplever du följande faktorer? (1= Mycket säkert- 10= Mycket osäkert): Kunskap och forskning	Pearson Correlation	.864**	1
	Sig. (2-tailed)	.003	
	N	9	9

**. Correlation is significant at the 0.01 level (2-tailed).

Appendix 4: Cronbach's Alpha SPSS

Scale: Cronbach's Alpha TU

Case Processing Summary

		N	%
Cases	Valid	9	100.0
	Excluded[a]	0	.0
	Total	9	100.0

a. Listwise deletion based on all variables in the procedure.

Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.729	.770	3