European Journal of Science and Mathematics Education, 2022, **10**(4), 555-569
ISSN: 2301-251X (Online)

OPEN ACCESS

Research Article

Mathematical Modelling in Upper Primary School: Finding Relevance and Value for Others Outside School

Frode Olav Haara [1*]
0000-0002-0825-1897

[1] Faculty of Education, Arts and Sports, Western Norway University of Applied Sciences, Sogndal, NORWAY
[*] Corresponding author: frode.olav.haara@hvl.no

Citation: Haara, F. O. (2022). Mathematical Modelling in Upper Primary School: Finding Relevance and Value for Others Outside School. *European Journal of Science and Mathematics Education, 10*(4), 555-569. https://doi.org/10.30935/scimath/12403

ARTICLE INFO

Received: 5 Jul 2022
Accepted: 19 Aug 2022

ABSTRACT

This article reports on how a pedagogical entrepreneurship approach combined with fundamental elements of mathematical modelling may be used to strengthen students' development of mathematical literacy in upper primary school. This is done first through a review of the relationship between pedagogical entrepreneurship in mathematics, mathematical modelling, and mathematical literacy, and then through presentation of a best-practice example where the pedagogical entrepreneurship approach and mathematical modelling have been the foundation for an assignment given to teacher education students. An action-research perspective influenced by self-study methodology has been used in identification and presentation of the best-practice example. The example shows that through emphasis on mathematical modelling and a scientific approach based on pedagogical entrepreneurship, we may have expectations towards increase of upper primary school students' development of mathematical literacy. In conclusion, key elements in pedagogical entrepreneurship like authenticity, relevance, and value for others enrich the mathematical modelling process, and provide valuable stepping-stones for the upper primary school students' development of mathematical literacy.

Keywords: pedagogical entrepreneurship, mathematical modelling, mathematical literacy

INTRODUCTION

By 2002, attention had been brought to the relation between development of mathematical literacy and the ability to develop and use mathematical modelling to deal with real-world problems in mathematics education (Blum, 2002). In a society that increasingly appreciates the ability to apply mathematical competence when one faces a problem, the development of mathematical literacy through school mathematics is still required (Haara et al., 2017; Bolstad, 2020; Sfard, 2014). Mathematical literacy was defined by the OECD in 1999 as

> "an individual's capacity to identify and understand the role that mathematics play in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen" (OECD, 1999, p. 14, as cited in Blum, 2002).

In 2016, World Economic Forum (WEF) launched a list of 10 human skills likely to become more important than others in the future (WEF, 2016). The top three skills on this list were complex problem-solving, critical thinking and creativity (WEF, 2016). National curriculum revisions pay attention to such signals, so that current and future students may attend schools that prepare them to live and work in our future society (e.g., Bocconi et al., 2018; OKM, 2018; Skolverket, 2019; UK Department of Education, 2014; Utdanningsdirektoratet, 2020).

For some time, mathematics education research has focused on relating mathematical literacy to students' everyday lives (e.g., Bolstad, 2020; Carraher et al., 1986; De Lange, 2003; Freudenthal, 1973; Haara, 2015; Tai & Lin, 2015). Haara (2018) suggests that one way of combining the development of mathematical literacy and relevance for students is through pedagogical entrepreneurship. According to Haara et al. (2016), pedagogical entrepreneurship is action-oriented teaching and learning in a social context, where the student is active in the learning process and where personal features, abilities, knowledge, and skills provide the foundation and direction for the learning processes. Such an approach entails the use of teaching methods that give students authority and activate learning awareness. It requires working methods that improve students' creative abilities and beliefs about their own skills, provide a basis for seeing opportunities around them, and motivate them to become development stakeholders in the community (Haara & Jenssen, 2019). A focus on entrepreneurial learning, thus, requires priorities regarding both processes and products in school subjects (Haara & Jenssen, 2016), which in turn means that a learning environment that emphasizes authenticity and student activity is considered fundamental. Therefore, pedagogical entrepreneurship is based on constructivist and sociocultural theories of learning (Røe Ødegård, 2015).

Haara et al. (2017) noted that researchers have concluded that specific attempts to work directly with mathematical literacy through mathematics alone does not work, and that it seems that teaching for mathematical literacy calls for something else than traditional mathematics teaching. Haara (2018) showed that problem-solving features, problem relevance, and student activity are recognized as valuable for the development of mathematical literacy, and that these could be emphasized through a pedagogical entrepreneurship approach. Kaplinsky (2020) and Smith and Stein (2018) provide further support for the influence of creativity and tolerance for ambiguity in school mathematics, through emphasis on problem solving and teaching based on problem-solving approaches.

However, despite thorough work within the mathematics education research community to put emphasis on mathematical modelling and unravel how this may be done with young students (e.g., English & Watters, 2005; Gravemeijer, 1999), this remains an issue in need of attention. According to Erbas et al. (2014), a mathematical model "is used to understand and interpret complex systems in nature" (p. 1622). When applying a modelling process in the teaching of mathematics, the underlying assumption is that students can learn fundamental mathematical concepts meaningfully during the modelling process in which they need the concepts while addressing a real-life problem-solving situation (Lesh & Doerr, 2003). Based on previous research it seems clear that emphasis on both mathematical literacy and mathematical modelling is better with a touch of relevance and real-world problem relation than with traditional word problems or quasi-real problems (Vos, 2018). In addition, Erbas et al. (2014) state that integrating modelling into mathematics education is important for improving students' problem-solving competence and analytical thinking abilities, and they call for more research on the use of modelling at different levels of education and examples of modelling tasks that can be used by teachers and in teacher education programs.

Haara (2018) used the pedagogical entrepreneurship approach to give two examples of how such integrated modelling may be applied in students' development of mathematical literacy in lower secondary school. The purpose of the article at hand is to respond to the calls made by Blum (2002), Bolstad (2020), Erbas et al. (2014), and Sfard (2014), and to present and discuss how pedagogical entrepreneurship and mathematical modelling may be combined to pave the way for the further development of mathematical literacy in upper primary school. The area of statistics is used as an example to illustrate the possibilities for such a combined effort, and the research question asked is therefore: *How can pedagogical entrepreneurship and mathematical modelling combine to pave the way for learning statistics in upper primary school?* Addressing this question provides the opportunity to discuss the possibilities for students' development of mathematical literacy, with emphasis on pedagogical entrepreneurship and mathematical modelling.

THEORETICAL BACKGROUND

Pedagogical Entrepreneurship

Pedagogical entrepreneurship is quite a new area of interest within research on teaching and learning. While entrepreneurship education has been well supported (European Commission, 2004; OECD, 2009), researchers have only recently started to look at pedagogical entrepreneurship (Haara et al., 2016). Implementation of pedagogical entrepreneurship in schools has been of significant concern since about 2010 according to EU (European Commission, 2010, 2011, 2013), OECD (2010), and policy documents in several countries (Lund et al., 2011). In pedagogical entrepreneurship, emphasis is placed on the importance of discovering resources and opportunities, and on methods to stimulate and develop them in such a way that one might act innovatively in both future work and social situations. Through such a line of argument, the school system is encouraged to develop students' qualifications in a way that provides a foundation for such acts in the future (Haara & Jenssen, 2019).

According to Haara and Jenssen (2019), the pedagogical entrepreneurship approach has much in common with other approaches with a long tradition in schools, such as problem-based learning and project work, which opens for recognition of emphasis on cooperative learning elements such as positive interdependence, interaction, individual responsibility, appropriate use of social skills and group processing (e.g., Chowdhury, 2021; Johnson & Johnson, 2009). Cooperative learning is here recognized as an educational technique that uses small groups of students guided by the teacher to benefit their individual and each other's learning (Chowdhury, 2021). Furthermore, pedagogical entrepreneurship also has more unique characteristics, such as prioritizing the ability to see opportunities, working innovatively, and demonstrating some willingness to take risks (Lackéus, 2015). It can be prioritized in and across subjects, by employing known working methods and through the development of new ones (Haara & Jenssen, 2016; Sagar, 2014). It is, therefore, a perspective for the work in schools that addresses many challenges highlighted both by socio-political stakeholders (European Commission, 2010, 2013; European Council, 2000) and by research in creativity and education (e.g., Dweck, 2006; Sawyer, 2012).

The entrepreneurial approach gives students authority. Their voice and form of expression are accommodated (Haara & Jenssen, 2019). By applying knowledge, the students experience the value of their knowledge and the need to learn more. Hence, they develop motivation for change and the ability to change. The approach also has a motivating effect on the students. In their schooling, they find that their voices are heard and that they become involved in all aspects of the teaching, that their creativity is strengthened, and that investigative and scientific approaches are facilitated. Key elements in such processes are that the school must be open to the outside world, use the resources that are around the school, and apply scientific approaches (Haara & Jenssen, 2019). This can help to ensure that knowledge is not seen as something that is isolated to its subject, but as something that creates integrated and rich learning opportunities (Thomson, 2012).

The next level of attention within pedagogical entrepreneurship is about creating values for oneself and others (Lackéus, 2016). By focusing on this perspective, students comprehend that what they do affects others. According to Lackéus (2016), this can give the students a sense of achievement and convey a strong message about the value of the present. Lackéus (2013) makes the point that we become more motivated by creating value for others in 15 minutes in near future than by creating value for ourselves 15 years from now. According to Haara and Jenssen (2019), this means that the pedagogical entrepreneurship approach makes it possible for students to develop skills and mindsets that can turn creative thoughts into action. They sum this up by emphasizing the facilitation of three key factors: student co-determination, relevance, and trust.

Student co-determination

The student needs to be active in terms of initiating, developing, and performing. Creativity and problem-solving can be learned (e.g., Kaplinsky, 2020), and Sawyer (2012) points out that the earlier one starts, the more likely one is to be able to handle such challenges. In other words, entrepreneurial qualities must be cultivated and nurtured if they are to develop. If a student is to benefit from working in a group, the student must, over time, be given chances to learn to work in such a way, for instance through cooperative learning (Johnson & Johnson, 2009). If a student is to see value in working with a scientific approach (investigate, obtain data, analysis, results, and reflection) and in being able to work at solving problems (analysis, planning, implementing plans, verifying), the student must be given the opportunity to work with such processes, with a gradual increase of complexity. Students do not develop their investigative and creative skills by working with a theme that is reduced to the reproduction of facts, or a problem reduced to an exercise. An entrepreneurial approach requires teachers to have the courage to relinquish some control and be open to investigative and creative working methods.

Relevance

Most things are motivating to work with if one regards the time and energy invested in them to be meaningful. Emphasis on the importance of co-determination, problem-solving, and the multidisciplinary approach, which typifies the entrepreneurial working method, can make it easier to see potential applications of the knowledge (Thomson, 2012; Wiggins, 2012).

Trust

Teachers must see opportunities rather than difficulties. If students are to experience a real sense of co-determination and relevance, they must know that they have influence, and they must feel that they are trusted within the framework that has been set out. Trust is not built through constant reminders of a controlling nature, such as through tests that reproduce facts, but by experiencing that the content one has chosen to work with, the way in which one has chosen to present or communicate, and the interpretations or arguments one has, are being taken seriously.

Mathematical Modelling

The field of applications and modelling in mathematics education has retained an important position within mathematics education research for about 50 years (Blum, 2002, 2015; Erbas et al., 2014; Van Dooren et al., 2019). About 20 years ago, Blum (2002) stated that "nearly all questions and problems in mathematics education, that is questions and problems concerning human learning and teaching of mathematics, affect and are affected by relations between mathematics and the real world" (p. 150-151). According to Van Dooren et al. (2019), when modelling a problem, the student has to use his/her knowledge of the real world and the problem at hand to develop an appropriate mathematical model for the situation and to make proper decisions about which mathematical operations to perform. Lehrer and Schauble (2003) describe a model as an attempt to construct an analogy between an unfamiliar system and a previously known or familiar system. Accordingly, people make sense of real-life situations and interpret them by using models. Lehrer and Schauble (2007) describe this sense-making process as model-based thinking and emphasize its developmental nature. Blum (2002) emphasizes the relation between mathematical modelling and the development of mathematical literacy, and he uses the 1999 OECD definition of mathematical literacy (quoted in the Introduction of this article) to underpin the opportunities that lie in the relations between the real world and mathematics. According to Blum (2002), emphasis on mathematical modelling in school is central to students developing mathematical literacy. Although opportunities have been shown, it has proven necessary to call for more research on how to pave the way for students' development of mathematical literacy (Bolstad, 2020; Erbas et al., 2014; Haara et al., 2017; Sfard, 2014).

Blum (2015) describes four reasons to use mathematical modelling in teaching: pragmatic, formative, cultural, and psychological. The pragmatic reason is that, to understand and handle everyday situations, students need to learn to transform problems into mathematics, and they will not be able to do this on their own if they only work with mathematics that is not related to such situations. The formative reason is that the use of modelling develops various competences within mathematics, such as modelling competence and argumentation competence. The cultural reason is to see the use of mathematics in society, to get an impression of what mathematics is as a science. Finally, the psychological reason is that examples from everyday life may evoke students' interest in mathematics, through the opportunity to structure mathematical content in a way that makes it easier for them to understand. In modelling, one starts with an everyday situation, transforms it so that it can be treated with the use of mathematical tools, and then the mathematical results are interpreted in relation to the everyday situation, which in turn makes the use of mathematical modelling a tool for use in the development of mathematical literacy.

Pedagogical Entrepreneurship, Mathematical Modelling, and Mathematical Literacy

Emphasis on mathematical literacy in school mathematics has been stressed for some time (e.g., Colwell & Enderson, 2016; De Lange, 2003; OECD, 2009, 2013; Sfard, 2014). In short, we find that works from Edo et al. (2013), Gatabi et al. (2012), and Tai and Lin (2015), for instance, connect mathematical literacy to problem solving and mathematical modelling. Haara (2018) shows how a pedagogical entrepreneurship approach may be used in lower secondary school to enhance students' development of mathematical literacy within calculus and geometry. In addition, Palmér and Johansson (2018) have investigated how problem solving can be emphasized through a pedagogical entrepreneurship approach in lower primary school. In the previous paragraphs, the connection between pedagogical entrepreneurship in mathematics and mathematical modelling has been derived, and it may be described using Blum's (2015) four reasons to use mathematical modelling in relation to pedagogical entrepreneurship. The pragmatic reason is the most obvious connection, because of the aim of understanding and handling everyday situations. Pedagogical entrepreneurship is based on experiences of relevance and authenticity for students. The formative and the cultural reasons represent two sides of the same argument for connection to pedagogical entrepreneurship, because students need to both develop various competences within mathematics and to see the use of mathematics in society, to fulfil the research-based and problem-solving approach within mathematics through their actions. The psychological reason is connected to pedagogical entrepreneurship through the requirement for students to experience, interpret and acknowledge the responses that relevant stakeholders in society give when checking the viability of the outcomes of the mathematical work the students have done.

METHOD

Research Perspective and Validity

The fact that the author of this article was the lecturer involved in the reported study, places this article within an action research perspective (e.g., Ulvik et al., 2016), influenced by self-study methodology (Cochran-Smith & Lytle, 2009; Zeichner, 2007). Within action research, the self-study methodology is a form of practitioner research. This method asks me as a lecturer to reflect on my practice for the purpose of improving it and the practice of others (Hamilton et al., 1998). The methodology aims "to understand teaching from the inside out rather than the outside in and to simultaneously put what is learned into practice" (Loughran, 2004, p. 154). Self-study is a kind of practice research or investigation of practice (LaBoskey, 2004; Zeichner, 2007). In the study reported in this article, this involved teacher education students who carried out an assignment meant for upper primary school students, and they reflected on their own practice as teachers with an aim of improving their own and others' practice. Together, we tried to understand the roles both as a student and as a teacher from the inside and out, rather than from the outside and in (Loughran, 2004). I prepared for a systematic investigation of practice, based on the teacher education students' collection of observation data, aimed towards the role as an upper primary school student and the role as a teacher, respectively, as the basis for analyzing the thoughts and experiences related to the use of such an activity as an example of how pedagogical entrepreneurship and mathematical modelling can combine to pave the way for the learning of statistics in upper primary school. In this article, the choice of methodology served two main purposes: professional development of the participants (lecturer and students involved), and enhanced understanding of how emphasis on pedagogical entrepreneurship and mathematical modelling together offer possibilities for students' development of mathematical literacy. This perspective was chosen because of the necessity of analysis related to possible normative effects provided by the study. The methodology was also chosen because of the proximity I could accomplish as both a lecturer and a researcher in relation to the example. Hence, to answer the research question in a trustworthy manner and offer mathematics teaching arguments for a "reframed thinking and transformed practice of the teacher" (LaBoskey, 2004, p. 844), I made it a priority to be as close as possible to the actual activity, and thereby sacrificed some observational distance on the altar of relevance. This means that I chose the problem to use in the teaching, tutored student groups, organized the presentations, and was responsible for the analysis of data. This provided an intended and appreciated interaction between practice and research focus, with awareness of the possible influence such a perspective may have on both the actual practice and the theoretical understanding of the practice (Kemmis, 2009).

The choice of methodology challenged my role as researcher because of the proximity to the production of data and, therefore, it has been important for me to remain aware of my roles as lecturer and researcher. Although Kvale and Brinkmann (2015) highlight knowledge about both the field of research and expertise within the field at hand as prerequisites for viable interpretations, I therefore considered it important to the project's overarching self-study-perspective to follow Feldman's (2003) criteria for securing validity and reliability in a self-study-based project:

1. To provide a detailed description of how data were collected and to make explicit what counts as data.
2. To provide detailed descriptions of how the presentation of data was constructed.
3. To include exploration and discussion of other ways to represent the same self-study, as one data set can lead to a variety of representations.
4. To show why one approach was chosen instead of others.
5. To provide evidence of the value of the changes in mathematics teaching and learning. Self-study is a moral and political activity. If self-study were to result in a change of mathematics teaching, then there should be some evidence of its value.

This is done through the next two paragraphs and the section that contains report of results.

Data Collection and Reflections on Impressions from Data

On this occasion, the self-study perspective offered data from two sources: teacher education students' reports from completing the assignment, and the lecturer's observations. Hence, this is not a regular, qualitative study primed to provide arguments for the reliability of empirical data. However, the study provides close contact with actual teaching and learning experiences, as well as research perspectives on these experiences through the discussion of possibilities and necessities regarding a relationship between pedagogical entrepreneurship in mathematics, mathematical modelling, and mathematical literacy. The study, therefore, also contains facets of a case-study perspective (Yin, 2014) through its purpose of developing understanding of the teaching experiences related to the study and the reliance on data that is difficult to replicate. The data from the junction will be easy enough to collect again and again, but it would probably be quite difficult to reproduce qualitative data from teacher education students because of the teacher education students' close involvement in both producing and collecting data, and the choice not to film or audio-record the process. As was the case for Haara (2018), the theme and design of this study required that the lecturer/researcher be part of the collected data and, thereby, in an unconscious manner, choose the experiences and impressions that would be subject to analysis. This may seem to be a rather unpredictable way to work in classroom research, but this is not an article about mathematics teaching and learning seen from the outside. It is an article about mathematics teaching opportunities experienced from the inside.

Analysis

Blum's (2015) four reasons for emphasis on mathematical modelling and the three key factors for a pedagogical entrepreneurship approach given by Haara and Jenssen (2019) have produced the analytical framework for the analyses. However, I regard the phenomenological condensation of impressions produced through the work done by the teacher education students, and my observations related to their work, to be inspired by the constant comparative analysis method (Glaser, 1965; Strauss & Corbin, 1998). The analyses were, given these conditions, completed in four phases:

1. Comparing impressions and incidents in categories,
2. Comparing categories and their qualities,
3. Delimiting the interpretation and understanding based on a summary of the categories and their qualities, and
4. Describing the interpretation and understanding as a basis for discussing the article research question and highlighting the significance of the presented focus for future mathematics teaching in schools.

The constant comparative analysis takes for granted that there is a continuous flow from phase to phase, but that all four phases are operational throughout the full analysis process and contribute to the development of the subsequent phase, until the analysis ends (Glaser, 1965). In this study, it means that new types of data continuously contributed to ensuring that the full analysis of the combining of pedagogical entrepreneurship key-factors and mathematical modelling reasons was further refined through an interaction between deduction and induction. The task given to the teacher education students was developed based on the lecturer's analyses of the obvious and possible connections between pedagogical entrepreneurship, mathematical modelling, and mathematical literacy, and the data produced by the teacher education students and by the observations of their presentations were added to the four phases of the constant comparative analysis approach. This means that the data were seen in conjunction with the previously collected and analyzed literature studies, and with the lecturer's beliefs and expectations, and that they both influenced the analysis of these and were themselves influenced by them when they were analyzed and seen in context with the prevailing interpretation and understanding (Haara, 2018). My own reflections on impressions from the data are based on three rounds of personal notes related to the three parts of the project: a first round immediately after the teacher education students had been given the assignment, with emphasis on organizational-, progress-, and result-based impressions, a second round when the teacher education student groups began to report informally to me about their data collection, and a third round after the groups had presented their work to their peer teacher education students and to me.

REPORT OF RESULTS FROM ONE TEACHER EDUCATION STUDENT GROUP

This section first presents the context of the study that was carried out in groups by the teacher education students, and then illustrates the way one of the groups completed this project, the data that were collected, and what was emphasized in the student group's considerations during their presentation.

In 2020, an assignment was introduced to two classes of mathematics teacher education students at a Norwegian teacher education institution. Important for the choice of this assignment was the renewal of the domestic curriculum (Utdanningsdirektoratet, 2020) with increased emphasis on general features such as problem solving, creativity, real-life relevance, sustainable development, and being a resource for the community, with a specific topic within school mathematics (here: statistics) as the starting point. In other words, the students were given the opportunity to work on a project-based example of how they may work in the future with their own upper primary school students, to emphasize mathematical literacy through pedagogical entrepreneurship and mathematical modelling. The goal for the students was two-fold–to carry out the actual content embedded in the assignment and to look into the organizational concerns that would be necessary to pay attention to when doing this work with upper primary school students. Through the latter goal, they were also asked to link project-based examples to the purpose of creating value for others, by being a resource in the local community and maintaining authenticity.

In Norway, the curriculum focuses on statistics from an early age, with lower primary school students starting to work on collecting data and presenting them in diagrams. When entering upper primary school (fifth to seventh grade), the students are also introduced to the calculation of mean values, the sense of probability, and the use of spreadsheets. In groups of three or four, the teacher education students were given the following assignment:

You are required to perform a real data collection. This will take place at the traffic junction of [anonymous] in the period 14.00-16.00 on a regular weekday (within the next week). The group should perform observations and records concerned with the motorized vehicles passing through the junction. The group chooses what to focus on, but remember to carefully explain what you record, why this is interesting to record, and who it might be interesting for. Save the data you collect and document how you recorded it.

Before you complete the data collection, study the two competence goals for statistics for upper primary level after grade 7 (Utdanningsdirektoratet, 2020) in the national curriculum, to find the statistical areas you want to focus on with upper primary school students in a project such as this (competence goals quoted from Utdanningsdirektoratet (2020) here translated into English):

The student should be able to:

1. Explore and use appropriate central goals in own and others' statistical survey.
2. Log, sort, present, and read data in tables and diagrams and justify the choice of presentation.

Figure 1. A photo of the traffic junction

Table 1. Real data on motorized vehicles' behavior at a specific traffic junction in Norway

Time/activity	14.00-14.20	14.20-14.40	14.40-15.00	15.00-15.20	15.20-15.40	15.40-16.00
Turns right at the junction	93	139	164	178	109	87
Turns left at the junction	2	7	3	5	7	1

You have ten hours to complete the project, including planning, data collection, data treatment, facilitating for presentation, and actual presentation. For the presentation you should also consider, when using this with an upper primary school class of about 20 students:

1. How the work may be organized, and
2. What practical consequences the students' results may have, and for whom.

The traffic junction used in the task is unique. At most times of day, the driver can choose to make a right or a left turn (**Figure 1**). However, no left turns are allowed between 07.00-09.00 in the morning or between 14.00-16.00 in the afternoon, because there is increased traffic pressure at these times. The students were instructed to collect their data in the latter period.

The four members of the student group were familiar with the junction used to collect the data, so they did not have to visit or review the layout before doing their observations. They decided to emphasize frequency using tables, bar graphs, and mean values from the area of statistics, and to use spreadsheets in the presentation of data and mathematical results. The main challenge in relation to the competence goals for the upper primary school was deciding what data to collect and how this could be done by upper primary school students. The students explained in their presentation that they ruled out a first idea about recording color, because there could be disagreement about what color a car actually was. They decided to use the information on the sign at the junction because it offered an obvious dichotomy (right turn/left turn) that students lower than seventh grade could also manage. They then decided that the two-hour span could be divided into 20-minute sessions, with a small group of students responsible for each session. In their opinion, shorter sessions would be less onerous for the students, and having only one small group of students present at a time (rather than the entire class of about 20 students, as referred to in the assignment brief) would be easier for both teachers and students to manage. Another argument for reducing the number of students present was that having 20 students and several teachers in bright yellow safety vests present would probably influence the traffic environment at the junction, affecting the validity of the data collected, because drivers would be aware that something unusual was happening.

The student group collected the data shown in **Table 1**, using two students for each 20-minute session, where one focused on the right-turning vehicles and the other on left-turning vehicles.

This data could be presented using bar graphs and provided the opportunity to work with mean values of both large and small numbers. The group presented the numbers as bar graphs (**Figure 2** and **Figure 3**) and discussed what these numbers might indicate.

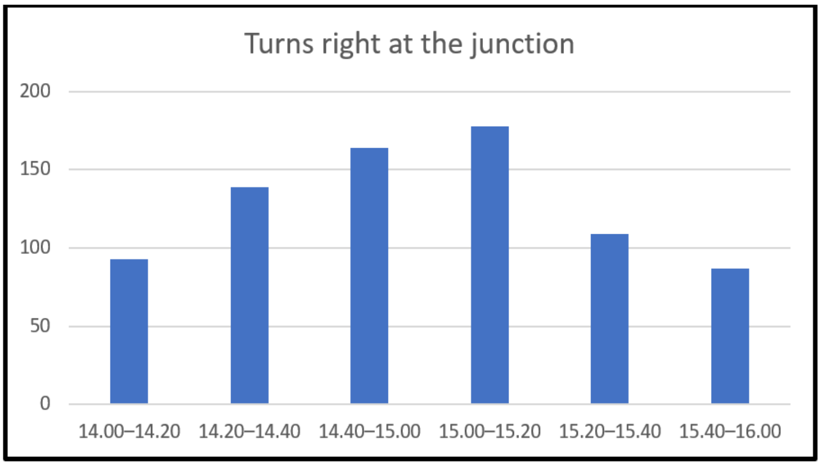

Figure 2. Motorized vehicles turning right between 14.00-16.00

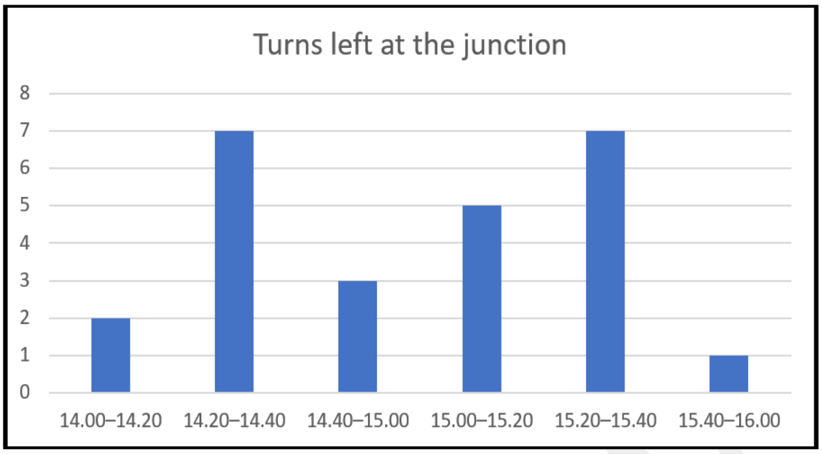

Figure 3. Motorized vehicles turning left between 14.00-16.00

Figure 2 shows the traffic that turns right between 14.00-16.00, in 20-minute sessions. The numbers confirm that there is increased traffic pressure at this junction between 14.00-16.00, and that this makes it reasonable to instruct the traffic movements through this period. The mean number of motorized vehicles turning right during a 20-minute period is about 128 vehicles, which is a significant amount of traffic for this particular junction. Allowing drivers, the choice of turning right or left during this time of day would easily jam the traffic.

Figure 3 shows the traffic that turns left between 14.00-16.00, in 20-minute sessions. The mean number of motorized vehicles turning left over the two-hour period was just over four, even though turning left was illegal at this time. The teacher education students calculated the standard deviation and estimated that about 2.5 vehicles turned left illegally during each 20-minute session between 14.00-16.00 at this junction.

The students then presented their views on the practical uses of the results the upper primary school students would have obtained in such a project, and the possible relevance for others. First, they acknowledged the decision made by the traffic authorities regarding the traffic instructions for the junction and argued for this through the use of the bar graphs, showing that traffic pressure peaks from 14.00-16.00, and that the forced right turn reduces traffic jams at the junction. They argued that this is because they saw with their own eyes that the consequence when someone ignored the instruction and attempted to make a left turn at the junction was that the traffic jammed almost every time. Second, they suggested that because such infringement occur often and disturb the traffic pattern, fines ought to be given. The standard deviation indicates that if police were covertly present at the junction, they would catch at least two drivers making a left turn and disturbing the traffic within every 20-minute session! Third, attention to the traffic pattern at this junction would be of interest to the local newspaper because of the junction's rather core position in the town. The teacher education students, therefore, concluded that a report made by seventh-grade students, in which they gathered data and structured, presented, and calculated results using statistics, and interpreted the results, comparing them with what goes on at the junction, would be of interest to the traffic authorities, the police, and the general public. To hand over such a report to representatives of the traffic authorities, the police, and the local newspaper, would be an example of how upper primary school students can experience that they are a resource in their local community and that what they do and learn in school may have relevance outside school and create value for others.

DISCUSSION

Through the given assignment, a conservative acquisition-based perspective on how to organize mathematics teaching was challenged (Cobb, 2007; Sfard, 1998). Darling-Hammond and McLaughlin (2011) note that competence may develop in what can be called informal work-based learning arenas, rather than in organized courses. However, the adaptation of impressions where the connections between theory and practice are reflected upon is necessary (Krawec & Montague, 2014). The teacher education students' learning was embedded in professional development opportunities within learning communities (Wenger, 1998), in which the participants cooperatively learn from and with each other (Johnson & Johnson, 2009).

Almost 20 years ago, Blum (2002, p. 152) made the following statement in relation to the teaching and learning of mathematical modelling:

> As we have seen, this topic not only deals with most of the essential aspects of the teaching and learning of mathematics at large, but it also touches upon a wide variety of versions of the real world outside mathematics that one seeks to model. Perceived in that way, the topic of applications and modelling may appear to encompass all of mathematics education plus a lot more. It is evident, therefore, that we have to find a way to conceptualize the topic so as to reduce the complexity to a meaningful and tractable level.

The learning through pedagogical entrepreneurship in mathematics challenges the more traditional, acquisition-based teaching processes, and might just be what Blum called for in mathematics education, both in regard to conceptualizing mathematical modelling and students' development of mathematical literacy. Through inductive, participative processes, the goal in pedagogical entrepreneurship is to reach beyond simply reproducing the curriculum. The challenge is to have students become more involved in their own professional development, and this is achieved through student co-determination in choices regarding content, approaches and priorities, relevance of assignments and projects, and the students' experience of the teacher's trust in them in various phases of an assignment or project. In other words, this is the way we want students to look upon the power of mathematical modelling. In the reported study, the teacher education students show how the representation of Blum's (2015) four reasons for using mathematical modelling, seen in relation to pedagogical entrepreneurship, is present in the work on learning statistics related to the data collection at the traffic junction, and thereby add to the body of knowledge about how one can emphasize mathematical modelling with young students (e.g., English & Watters, 2005; Gravemeijer, 1999). The pragmatic reason is present in the use of an everyday situation that creates some challenges in society. The junction is often jammed; why does this happen? What can be done? The formative and cultural reasons are present in the students' need to learn new mathematical content within statistics, and to use this in data collection and the analysis of data they have collected. What is relevant data? Why is it relevant? How can we present data in a way that is valuable for others? Hence, the research approach becomes visible. Young students work on research questions and viable methods for collecting and handling data, because the results and conclusions might be of interest and value to others. Finally, the psychological reason is found in the students' interpretation of the analyses they have performed on the data from the junction, how it is brought back to the real world for a viability check, and the responses that they experience from others, when they deliver their report to stakeholders in the local society, such as the local newspaper, traffic authorities, and police.

Learning through an approach that activates students' interests and resources, and underpins the ability to see opportunities, take initiatives, and organize targeted work, demands that the teacher is open to creative initiatives and provides viable frames. The opportunities for such orchestration are rich, and the teacher must guide and support the students in their work, but not deprive them of the opportunity to be creative, strive, and make decisions. This is part of the students' self-regulation development (Haara, 2018). The combination of problem solving, authenticity, mathematical modelling, and student activity paves the way for students to develop action competence in mathematics. This will enhance their experience with everyday life mathematics and, thus, strengthen their mathematical literacy. The junction assignment provides only one such opportunity. Other possibilities may be, for instance, recording of driving and parking right outside the school before and after the school-day starts and ends, or the collection, category coding, and reporting on garbage at a particular area near the school. The students and teachers need to find scenarios that students find relevant to work with and that may have value for others.

Simultaneously, there will be expectations about the students' ability to handle such challenges as the junction task provides, both with regard to mathematical content and the exploitation of autonomous frames provided by a pedagogical entrepreneurship approach. Pedagogical entrepreneurship as a learning strategy may appear to be demanding for students who are familiar and content with traditional teaching. This may lead to conflicts, for instance when the teacher makes priorities that are not necessarily coherent with the school curriculum or when the student is not offered suggestions for the solution of a problem. Research has shown that students find the latter challenging, because their previous experiences with mathematical exercises usually include comparison with a set answer, and mathematics teachers tend to reduce problems to exercises through their desire to help (Kaplinsky, 2020; Smith & Stein, 2018). The pedagogical entrepreneurship approach represents an alternative way to learn, and the teacher must, therefore, be aware that the traditional instructor becomes more and more replaced by the supervisor and co-researcher. This means that it is not possible to ignore teachers' views about learning mathematics and their opinions of what may be the best approach when emphasizing a process-based learning strategy in the teaching of mathematics. This raises questions about whether mathematics is mainly about calculation rules and algorithmic thinking, or whether it is also about creative thinking, making assumptions, and the consequences of assumptions made. The answer is two-fold, but if mathematical modelling and mathematical literacy is to stand a chance in school mathematics, students must be allowed to try, to fail with a purpose and an acknowledgment of the importance of this failure, and to fail again and again, but to fail in a better way each time. The viability check provided by bringing the results of mathematical modelling back to real-life, and experiencing relevance and value for others, might just be the acknowledgement a young student needs to experience the power of mathematical modelling and scientific rigor, and to develop inner motivation for problem solving, creation, and creativity in mathematics–or in short, to become mathematically literate.

CONCLUSIONS

In this article, I have reported how a pedagogical entrepreneurship approach combined with fundamental elements of mathematical modelling may be used to strengthen students' development of mathematical literacy in upper primary school. This has called for a review of the relationship between pedagogical entrepreneurship in mathematics, mathematical modelling, and mathematical literacy. It involved identification of elements from pedagogical entrepreneurship and their relation to mathematical modelling, and the presentation of a best practice example in which the pedagogical entrepreneurship approach and mathematical modelling have been used. The conclusion is that through emphasis on mathematical modelling and a scientific approach based on pedagogical entrepreneurship, we may have expectations towards increase of upper primary school students' development of mathematical literacy. Problem solving and scientific rigor are key in both mathematical modelling and pedagogical entrepreneurship, and the idea behind each of these is to interpret one's results and apply them in real-world practice. Therefore, key elements in pedagogical entrepreneurship like authenticity, relevance, and value for others enrich the mathematical modelling process, and provide valuable stepping-stones for the upper primary school students' development of mathematical literacy. The reported study shows that it is possible to plan for the learning of scientific approaches, data collection, mathematical modelling, and value for others, while learning statistics, in upper primary school. This planning needs to be based on the acknowledgement of compulsory school students as a resource when they are in school. They do not have to wait until they have finished school but can help move society forward while they learn mathematics and how to work scientifically. The development of mathematical literacy occurs through an emphasis on relevance, which is identified as the application of mathematical modelling and real-life viability checks of mathematical work, and through providing value for others, which is identified as the application of pedagogical entrepreneurship in mathematics for local sustainability and development.

The reported attempt to show that it is possible to teach for development of mathematical literacy through joint emphasis on a pedagogical entrepreneurship approach and mathematical modelling in mathematics teaching opens for further research. Longitudinal studies that aim to measure success and learning effects of such teaching priorities will add valuable knowledge to the field, opening for both quantitative and qualitative approaches to be represented. In addition, small scale projects based on design-based-research approaches (e.g., Anderson & Shattuck, 2012) developed together with mathematics teachers in school, will provide qualitative data that will also add to the body of knowledge about how one may succeed in teaching for young students' development of mathematical literacy.

Funding: The author received no financial support for the research and/or authorship of this article.

Declaration of interest: The author declares no competing interest.

Data availability: Data generated or analyzed during this study are available from the author on request.

REFERENCES

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher*, *41*(1), 16-25. https://doi.org/10.3102/0013189X11428813

Blum, W. (2002). ICME study 14: Applications and modelling in mathematics education–Discussion document. *Educational Studies in Mathematics*, *51*(1-2), 149-171. https://doi.org/10.1023/A:1022435827400

Blum, W. (2015). Quality teaching of mathematical modelling: What do we know, what can we do? In *Proceedings of the 12th International Congress on Mathematical Education* (pp. 73-96). Springer. https://doi.org/10.1007/978-3-319-12688-3_9

Bocconi, S., Chioccariello, A., & Earp, J. (2018). The Nordic approach to introducing computational thinking and programming in compulsory education. *Nordic@BETT2018 Steering Group*. http://www.itd.cnr.it/doc/CompuThinkNordic.pdf

Bolstad, O. H. (2020). *Teaching and learning for mathematical literacy* [PhD thesis, University of Agder].

Carraher, T. N., Carraher, D. W., & Schliemann, A. D. (1985). Mathematics in the streets and in school. *British Journal of Developmental Psychology*, *3*(1), 21-29. https://doi.org/10.1111/j.2044-835X.1985.tb00951.x

Chowdhury, T. A. (2021). Fostering learner autonomy through cooperative and collaborative learning. *Shanlax International Journal of Education, 10*(1), 89-95. https://doi.org/10.34293/education.v10i1.4347

Cobb, P. (2007). Putting philosophy to work: Coping with multiple theoretical perspectives. In F. K. Lester, Jr. (Ed.), *Second handbook of research in mathematics teaching and learning: A project of the national council of teachers of mathematics* (pp. 3-38). Information Age Publishing.

Cochran-Smith, M., & Lytle, S. L. (2009). *Inquiry as stance: Practitioner research for the next generation.* Teachers College Press.

Colwell, J., & Enderson, M. C. (2016). "When I hear literacy": Using pre-service teachers' perceptions of mathematical literacy to inform program changes in teacher education. *Teaching and Teacher Education*, *53*, 63-74. https://doi.org/10.1016/j.tate.2015.11.001

Darling-Hammond, L., & McLaughlin, M. W. (2011). Policies that support professional development in an era of reform. *Phi Delta Kappan*, *92*(6), 81-92. https://doi.org/10.1177/003172171109200622

De Lange, J. (2003). Mathematics for literacy. In B.L. Madison, & L. A. Steen (Eds.), *Quantitative literacy: Why numeracy matters for schools and colleges* (pp. 75-89). The National Council on Education and the Disciplines.

Dweck, C. (2006). *Mindset: The new psychology of success.* Random House.

Edo, S. I., Hartono, Y., & Putri, R. I. I. (2013). Investigating secondary school students' difficulties in modeling problems PISA-model level 5 and 6. *Indonesian Mathematical Society Journal on Mathematics Education*, *4*(1), 41-58. https://doi.org/10.22342/jme.4.1.561.41-58

English, L. D., & Watters, J. J. (2005). Mathematical Modeling in the Early School Years*.* *Mathematics Education Research Journal*, 16*(3)*, 58-79. https://doi.org/10.1007/BF03217401

Erbas, A. K., Kertil, M., Cetinkaya, B., Cakiroglu, E., Alacaci, C., & Bas, S. (2014). Mathematical modeling in mathematics education: Basic concepts and approaches. *Educational Sciences: Theory and Practice*, *14*(4), 1621-1627.

European Commission. (2004). *Making progress in promoting entrepreneurial attitudes and skills through primary and secondary education.* Final report of the Expert Group "Education for Entrepreneurship". Enterprise Directorate-General.

European Commission. (2010). *Towards greater cooperation and coherence in entrepreneurship education.* European Commission.

European Commission. (2011). *Entrepreneurship education: Enabling teachers as a critical success factor.* European Commission.

European Commission. (2013). *Entrepreneurship 2020 Action Plan: Reigniting the entrepreneurial spirit in Europe.* European Commission.

European Council. (2000). *Lisbon European Council 23/24 March 2000–Presidency conclusions*. https://www.ab.gov.tr/files/ardb/evt/1_avrupa_birligi/1_4_zirveler_1985_sonrasi/2000_3_lizbon_zirvesi_baskanlik_sonuc_bildirgesi_ekler_en.pdf

Feldman, A. (2003). Validity and quality in self-study. *Educational Researcher*, *32*(3), 26-28. https://doi.org/10.3102/0013189X032003026

Freudenthal, H. (1973). *Mathematics as an educational task*. Reidel. https://doi.org/10.1007/978-94-010-2903-2_2

Gatabi, A. R., Stacey, K., & Gooya, Z. (2012). Investigating grade nine textbook problems for characteristics related to mathematical literacy. *Mathematics Education Research Journal*, *24*(4), 403-421. https://doi.org/10.1007/s13394-012-0052-5

Glaser, B. G. (1965). The constant comparative method of qualitative analysis. *Social Problems*, *12*(4), 436-445. https://doi.org/10.1525/sp.1965.12.4.03a00070

Gravemeijer, K. (1999). How emergent models may foster the constitution of formal mathematics. *Mathematical Thinking and Learning*, 1*(2)*, 155-177. https://doi.org/10.1207/s15327833mtl0102_4

Haara, F. O. (2015). Teachers' choice of using practical activities – A hierarchical classification attempt. *European Journal of Science and Mathematics Education*, *3*(4), 323-336. https://doi.org/10.30935/scimath/9441

Haara, F. O. (2018). Pedagogical entrepreneurship in school mathematics: An approach for students' development of mathematical literacy. *International Journal for Mathematics Teaching and Learning*, *19*(2), 253-268.

Haara, F. O., & Jenssen, E. S. (2016). Pedagogical entrepreneurship in teacher education – What and why? *Icelandic Journal of Education*, *25*(2), 183-196.

Haara, F. O., & Jenssen, E. S. (2019). The influence of pedagogical entrepreneurship in teacher education. In J. Lampert (Ed.). *The Oxford encyclopedia of global perspectives on teacher education*. Oxford University Press. https://doi.org/10.1093/acrefore/9780190264093.013.754

Haara, F. O., Bolstad, O. H., & Jenssen, E. S. (2017). Research on mathematical literacy in schools – Aim, approach and attention. *European Journal of Science and Mathematics Education*, *5*(3), 285-313. https://doi.org/10.30935/scimath/9512

Haara, F. O., Jenssen, E. S., Fossøy, I., & Røe Ødegård, I. K. (2016). The ambiguity of pedagogical entrepreneurship: The state of the art and its challenges. *Education Inquiry*, *7*(2), 183-210. https://doi.org/10.3402/edui.v7.29912

Hamilton, M. L., Pinnegar, S., Loughran, J., Russell, T., & LaBoskey, V. (1998). *Reconceptualizing teaching practice: Self-study in teacher education*. Falmer Press.

Johnson, D. W. & Johnson, R. T. (2009). An educational psychology success story: Social interdependence theory and cooperative learning. *Educational Researcher*, *38*(5), 365-379. https://doi.org/10.3102/0013189X09339057

Kaplinsky, R. (2020). *Open middle math: Problems that unlock student thinking, grades 6-12*. Stenhouse Publishers.

Kemmis, S. (2009). Action research as a practice-based practice. *Educational Action Research*, *17*(3), 463-474. https://doi.org/10.1080/09650790903093284

Krawec, J., & Montague, M. (2014). The role of teacher training in cognitive strategy instruction to improve math problem solving. *Learning Disabilities: Research and Practice*, *29*(3), 126-134. https://doi.org/10.1111/ldrp.12034

Kvale, S., & Brinkmann, S. (2015). *Det kvalitative forskningsintervju* [*The qualitative research interview*]. Gyldendal Akademisk.

LaBoskey, V. K. (2004). The methodology of self-study and its theoretical underpinnings. In J. J. Loughran, M. L. Hamilton, V. K. LaBoskey, & T. Russell (Eds.), *International handbook of self-study of teacher education practices* (pp. 817-869). Kluwer Academic Publishers. https://doi.org/10.1007/978-1-4020-6545-3_21

Lackéus, M. (2013). *Developing entrepreneurial competencies: An action-based approach and classification in entrepreneurial education.* Chalmers University of Technology.

Lackéus, M. (2015). *Entrepreneurship in education: What, why, when, how. Entrepreneurship 360. Background paper for OECD.* https://www.oecd.org/cfe/leed/BGP_Entrepreneurship-in-Education.pdf

Lackéus, M. (2016). *Value creation as educational practice–Towards a new educational philosophy grounded in entrepreneurship?* [PhD thesis, Chalmers University of Technology].

Lehrer, R., & Schauble, L. (2003). Origins and evaluation of model-based reasoning in mathematics and science. In R. Lesh, & H. M. Doerr (Eds.), *Beyond constructivism: Models and modeling perspectives on mathematics problem solving, learning, and teaching* (pp. 59-70). Lawrence Erlbaum. https://doi.org/10.4324/9781410607713

Lehrer, R., & Schauble, L. (2007). A developmental approach for supporting the epistemology of modeling. In W. Blum, P. L. Galbraith, H.-W. Henn, & M. Niss (Eds.), *Modeling and applications in mathematics education* (pp. 153-160). Springer. https://doi.org/10.1007/978-0-387-29822-1_14

Lesh, R., & Doerr, H. M. (2003). Foundations of a models and modeling perspective on mathematics teaching, learning, and problem solving. In R. Lesh, & H. M. Doerr (Eds.), *Beyond constructivism: Models and modeling perspectives on mathematics problem solving, learning, and teaching* (pp. 3-33). Lawrence Erlbaum.

Loughran, J. J. (2004). Learning through self-study: The influence of purpose, participants and context. In J. J. Loughran, M. L. Hamilton, V. K. LaBoskey, & T. Russell (Eds.), *International handbook of self-study of teaching and teacher education practices* (pp. 151-192). Kluwer Academic Publishers. https://doi.org/10.1007/978-1-4020-6545-3_5

Lund, B., Lindfors, E., Dal, M., Sjøvoll, J., Svedberg, G., Borup Jensen, J., Ovesen, S., Rotefoss, B., Pedersen, O., & Thordardottir, T., (2011). *Kreativitet, innovasjon og entreprenørskap i utdanningssystemene i Norden: Bakgrunn og begrepsinnhold basert på politisk initiering og strategivalg* [*Creativity, innovation, and entrepreneurship in the educational systems on the Nordic venue: Background and conceptual content based on political initiation and strategy choices*]. Nordisk Ministerråd.

OECD. (2009). PISA 2009 assessment framework: Key competencies in reading, mathematics and science. *Organisation for Economic Co-operation and Development*. http://www.oecd.org/pisa/pisaproducts/44455820.pdf

OECD. (2013). OECD skills outlook 2013: First results from the survey of adult skills. *Organisation for Economic Co-operation and Development*. http://skills.oecd.org/OECD_Skills_Outlook_2013.pdf

OKM. (2018). Tasa-arvoisen peruskoulun tulevaisuus [The future of equal basic education]. *Opetus-ja kulttuuriministeriö* [*Ministry of Education and Culture*].

Palmér, H., & Johansson, M. (2018). Combining entrepreneurship and mathematics in primary school–What happens? *Education Inquiry*, *9*(4), 331-346. https://doi.org/10.1080/20004508.2018.1461497

Røe Ødegård, I. K. (2015). Pedagogisk entreprenørskap–begrep og begrunnelser [*Pedagogical entrepreneurship–Concept and justifications*]. In F. O. Haara, & I. K. Røe Ødegård (Eds.), *Grunnskolelærerutdanning gjennom pedagogisk entreprenørskap* [*Teacher education through pedagogical entrepreneurship*] (pp. 23-44). Cappelen Damm.

Sagar, H. (2014). *Teacher change in relation to professional development in entrepreneurial learning* [PhD thesis, Göteborgs Universitet].

Sawyer, R. K. (2012). *Explaining creativity–The science of human innovation*. Oxford University Press.

Sfard, A. (1998). On two metaphors for learning and the dangers of choosing just one. *Educational Researcher*, *27*(2), 4-13. https://doi.org/10.3102/0013189X027002004

Sfard, A. (2014). Why mathematics? What mathematics? In M. Pirici (Ed.), *The best writing of mathematics 2013* (pp. 130-142). Princeton University Press. https://doi.org/10.1515/9781400847990-015

Skolverket. (2019). LGR11 [The national curriculum of Sweden]. *Skolverket*. https://www.skolverket.se/getFile?file=4206

Smith, M. S., & Stein, M. K. (2018). *5 practices for orchestrating productive mathematics discussions*. Corwin.

Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory.* SAGE.

Tai, W. C., & Lin, S. W. (2015). Relationship between problem-solving style and mathematical literacy. *Educational Research and Reviews*, *10*(11), 1480-1486. https://doi.org/10.5897/ERR2015.2266

Thomson, P. (2012). Creative school and system change. In J. Sefton-Green, P. Thomson, K. Jones, & L. Bresler (Eds.), *The Routledge international handbook of creative learning* (pp. 333-336). Routledge.

UK Department of Education. (2014). *National curriculum for England to be taught in all local authority-maintained schools*. https://www.gov.uk/government/collections/national-curriculum

Ulvik, M., Riese, H., & Roness, D. (2016). *Å forske på egen praksis. Aksjonsforskning og andre tilnærminger til profesjonell utvikling i utdanningsfeltet* [*To do research on one's own practice. Action research and other approaches to professional development within the field of education*]. Fagbokforlaget.

Utdanningsdirektoratet. (2020). Læreplanverket [The national curriculum of Norway]. *Utdanningsdirektoratet*. https://www.udir.no/laring-og-trivsel/lareplanverket/

Van Dooren, W., Lem, S., De Wortelaer, H., & Verschaffel, L. (2019). Improving realistic word problem solving by using humor. *Journal of Mathematical Behavior*, *53*, 96-104. https://doi.org/10.1016/j.jmathb.2018.06.008

Vos, P. (2018). "How real people really need mathematics in the real world"–Authenticity in mathematics education. *Education Sciences*, *8*(4), 1-14. https://doi.org/10.3390/educsci8040195

WEF. (2016). The 10 skills you need to thrive in the Fourth Industrial Revolution. *World Economic Forum*. https://www.weforum.org/agenda/2016/01/the-10-skills-you-need-to-thrive-in-the-fourth-industrial-revolution/

Wenger, E. (1998). *Communities of practice: Learning, meaning and identity*. Cambridge University Press. https://doi.org/10.1017/CBO9780511803932

Wiggins, G. (2012). Creative learning. In J. Sefton-Green, P. Thomson, K. Jones, & L. Bresler (Eds.), *The Routledge international handbook of creative learning* (pp. 320-332). Routledge.

Yin, R. K. (2014). *Case study research–Design and methods*. SAGE.

Zeichner, K. (2007). Accumulating knowledge across self-studies in teacher education. *Journal of Teacher Education*, *58*(1), 36-46. https://doi.org/10.1177/0022487106296219