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Pedagogical rationales of flipped learning in the accounts of Finnish mathematics teachers

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ABSTRACT

The focus of this study is on the pedagogy of flipped learning (FL) in mathematics teaching. There has been extensive research into FL, but less research on teachers' pedagogical rationales when adopting this pedagogy. The present study addresses this research gap by examining interviews with mathematics teachers in Finland. These teachers identified themselves as FL advocates. A thorough analysis of the teacher interview data inspired by a grounded theory approach revealed three main pedagogical rationales for FL in the teachers' accounts, namely, Individualising Learning, Fostering Self-regulated Learning, and Fostering Engagement. Individualising Learning emphasises attempts to differentiate and humanise learning mathematics in heterogeneous student groups. Fostering Self-regulated Learning highlights the teachers' emphasis on students' responsibility in goal-oriented activity that is supported by self-paced learning. Fostering Engagement is related to the teachers' attempts to create a personally motivating learning environment for students. The results of this study contribute to the research into FL in two ways. First, the teachers of FL view self-regulation as an objective of education, and not just as a means of education. Second, the teachers underscore general learning skills over disciplinary learning in mathematics.

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Flipped learning; flipped classroom; pedagogical rationales; mathematics teaching

Introduction

This study contributes to an emerging line of research around flipped learning (FL). It examines teachers' practical work and how to change teaching methods from traditional and passive learning culture to more active, student-centred education (Lundin et al., 2018; Strelan et al., 2020). Since 2011, when Salman Khan used the term "flipping the classroom" in his TED talk (Khan, 2011), research interest in FL and in its precursor Flipped Classroom (FC) has grown rapidly at all school levels (e.g. De Araujo et al., 2017; Fung et al., 2021; Lo & Hew, 2017; Lo Hew, & Chen, 2017; Lopes & Soares, 2018; Lundin et al., 2018; Naccarato & Karakok, 2015; O'Flaherty & Phillips, 2015; Song & Kapur, 2017; Strelan et al., 2020). Although this study is part

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of the research into FL, we have included FC studies in the brief literature overview. In fact, FL and FC have often been used as synonyms in previous research (e.g. in all meta-studies cited above).

The term "flipped" refers to reversed classroom practices. This means that teachers do not use classroom time to introduce new content. One of the most-cited definitions of FC comes from Bishop and Verleger (2013). They refer to FC as "an educational technique that consists of two parts: interactive group learning activities in the classroom, and direct computer-based individual instruction outside the classroom" (p. 5). In 2014, the Flipped Learning Network introduced the term FL with the following definition:

> Flipped Learning is a pedagogical approach in which direct instruction moves from the group learning space into an individual learning space, and the resulting group space is transformed into a dynamic, interactive learning environment where the educator guides students as they apply concepts and engage creatively in the subject matter (Flipped Learning Network, 2014).

At the time of the inception of FL, more than 20,000 members in the FL network described themselves as Flipped Classroom professionals. The FL network coined the term "Flipped Learning" in reaction to what they considered to be a misconception amongst teachers, the media, and even among researchers. In their view, it was a misconception to consider FC only as a technical change in teaching (Flipped Learning Network, 2014). One major challenge in understanding "flipping" has been the trend of like-minded teachers to follow the fashion with no real pedagogical understanding or reflection (see, Fullan, 1993). They start implementing practical changes without a profound reflection on what they are doing. We often hear stories about students left to their own devices in learning described as FC (Toivola, 2020). When the FL network introduced the term FL, they wanted to direct the attention to flipping as an advanced pedagogical approach with the focus on students as individuals in every class during every school day (Bergmann & Sams, 2014; Toivola, 2020; Toivola et al., 2017).

Research on FL and FC has shed light on their impact on student learning outcomes as well as on challenges in their implementation. FL and FC have a moderate positive effect on students' performances at all school levels (Strelan et al., 2020). These methods have been shown to promote shared responsibility between students and teachers (McLaughlin et al., 2014). They also allow teachers to engage directly with students (Gannod et al., 2008; Lo et al., 2017; Lundin et al., 2018; Mason et al., 2013; McLaughlin et al., 2014; Prober & Khan, 2013; Strayer, 2012). The most frequently reported challenges in implementing FL and FC are first, teachers' lack of knowledge or experience in using these methods (Lo et al., 2017; Lundin et al., 2018); second, students' lack of self-regulation skills (Cheng et al., 2019; Lai & Hwang, 2016; Mason et al., 2013); and third, students' disengagement in out-of-class learning (Lo & Hew, 2017). To address these challenges, we need to evaluate, theorise, and research FL in pedagogical terms (Abeysekera & Dawson, 2015; Toivola & Silfverberg, 2015). In this study, the interest is not in flipping as an educational technique (see, Bishop & Verleger, 2013) or how it reverses traditional teaching paradigms. Instead, in this research we have concentrated on the pedagogical rationales teachers follow when they choose to adopt FL in their teaching of mathematics.

There are two major limitations in existing research on FL. The first is connected to one of the more frequently reported challenges mentioned before: flipping practices are often new for teachers who participate in studies. Although FL originates from teachers' practical work and their personal enthusiasm to change teaching practices (Lundin et al., 2018; Strelan et al., 2020), few studies have focused on teachers and their pedagogical rationales for using FL in their teaching (De Araujo et al., 2017; Lopes & Soares, 2018; Toivola, 2016; Toivola et al., 2017). Instead, FL studies seem mainly to focus on introducing FL as an educational initiative by school districts, teacher educators and instructional designers (De Araujo et al., 2017). It is crucial to offer more research results on teachers' perspectives in using FL in classrooms, given that the sustainability of educational innovations forms a critical challenge for educational research (Fishman et al., 2011) and that teachers' perspectives and needs often diverge from those of researchers who design interventions (Hofmann & Mercer, 2016). The second limitation is that earlier research has been driven by a strong will to standardise FL as a concept. Typically, FL is characterised by teachers using instructional videos as mandatory pre-class activities (see, e.g. Cheng et al., 2019; Lo & Hew, 2017; Lo et al., 2017; Lundin et al., 2018; Muir & Geiger, 2016). Although videos do help in reversing traditional teaching paradigms, they might not reveal the real reasons why teachers value FL in teaching and learning of mathematics and what they try to achieve with it.

In Finland, mathematics teachers, especially in lower and secondary schools, became enthusiastic about flipping almost a decade ago (Toivola, 2020; Toivola et al., 2017). We wanted to extend the research on FL and the pedagogy related to FL. Therefore, the focus here is on teachers' pedagogical rationales for using FL in teaching mathematics in Finnish schools. In our study, "pedagogical rationale" refers to long-term visions and goals of teachers to understand the purpose of teaching (practices) and how to use available learning resources (e.g. teaching materials and pedagogical ideas). Semi-structured interviews with four Finnish teachers (from primary, lower secondary, and upper secondary school levels) were used to describe teachers' rationales in FL mathematics classrooms. The research questions were:

- What pedagogical rationales, practices, and tools can be identified in the teachers' accounts of FL?
- How do teacher's pedagogical FL rationales relate to teaching mathematics?

Theoretical framework

From a sociocultural theoretical perspective, we understand that FL is a pedagogical approach that can be defined as a purposive cultural intervention in human development. The intervention is informed and shaped by the values and history of the surrounding society (Alexander, 2008; see also, Rajala et al., 2016). This definition leads us to examine and theorise the following question: to what extent does FL involve a substantial redefinition and reorganisation of underlying rationales of classroom practices and tools? Pedagogical rationales mean long-term visions and goals that teachers have about their work. These visions are partly shaped by sociocultural and institutional conditions (Biesta et al., 2015; Rajala & Kumpulainen, 2017). Various rationales can be identified among different FL-inspired pedagogical approaches, and these include specific ways of organising learning and instruction as well as selecting and using pedagogical tools to achieve students' learning outcomes. It is important to consider pedagogical rationales because it does not make sense to talk about teaching or learning without a purpose (Biesta, 2013).

Pedagogical rationales and their implementation reflect sociohistorical and cultural contexts and conditions of teachers' work (Alexander, 2008; Daniels, 2009). The context of this study, the Finnish education system, has not adopted the internationally popular standards in school learning and test-based accountability policies. Instead, the Finnish system is based on trust in the governance of education and provides teachers with a high level of autonomy and professionalism (Miettinen, 2012; Sahlberg, 2007; Simola, 2015). Professionalism refers to teachers' pedagogical judgment and deliberation in response to complex demands in teaching. These might be inhibited if teachers are monitored for adherence to detailed delivery of a curriculum (Edwards, 2001).

Pedagogical tools that teachers use to reach their goals shape their actions and interactions (Vygotsky, 1978). However, the availability of pedagogical tools can potentially limit teachers' possibilities to implement different FL versions. At the minimum, teachers might create tools, such as instructional videos to implement a version of FL. An examination of tools used by teachers and the ways they use them to meet their intentions can provide some insight into how they interpret and value various aspects in teaching practices. Indeed, how tools are used constitutes their meaning in practice; the meaning is not only in the material tool itself.

Song and Kapur (2017) gave examples on how using the same video clip as a learning tool can lead to two versions of FL, with implications for learning outcomes. They compared two FL designs in which students watched the same video clips in a two-week curricular unit on polynomials for grade 7 mathematics. In these designs the purposes of the same video clips were divergent: the first pedagogical design in the video watching phase "focused on acquisition of basic knowledge of the topic before problem solving"; the second pedagogical design in the video watching phase "focused on consolidating the concept that students learned in their process of problem solving" (Song & Kapur, 2017, p. 302). In these different FL designs, the nature of learning mathematics was divergent: with the former centred on the development of procedural knowledge, and the latter centred on development of conceptual knowledge and knowledge transfer.

Data collection

This study forms a part of a larger research project investigating FL teachers and their pedagogy. The study focuses on teachers' pedagogical rationales for adopting FL while examining data from teacher interviews. Interviews were conducted with four teachers from Finland who have used FL as a pedagogical approach when teaching mathematics for several years at primary and secondary levels. The teachers identified themselves as FL advocates. Teachers in Finland have a high level of autonomy to design their pedagogical principles and to prepare their teaching independently (e.g. Niemi & Nevgi, 2014; Sahlberg, 2012). The teachers interviewed in this study were from publicly funded schools in the metropolitan area.

The study data consist of in-depth, two-hour long semi-structured individual interviews conducted in autumn 2014 with four teachers. At the time of interview, Mark was a 40-year-old male primary school teacher. He had worked as a teacher for 11 years and had used FL for two years. Mary was a 38-year-old female lower secondary school teacher (grades 7–9). She had worked as a teacher for 14 years and had used FL for three years but had been using FL elements occasionally since 2004. Jack was a 28-year-old male lower and upper secondary teacher. He had worked as a teacher for two years and had used FL for one year. Peter was a 33-year-old male upper secondary school teacher. He had worked as a teacher for eight years and had used FL for five years.

In this conversational open-ended interview (Turner, 2010), our interest was to understand the teachers' personal ways of approaching the teaching of mathematics as FL teachers. Choosing an open-ended conversational method served our ambitions not to define FL on behalf of the teachers but rather to give room for the teachers' own interpretations, in which the teachers considered FL in the context of their "current learning culture". In line with a sociocultural understanding of learning and pedagogy that informs this study (Alexander, 2008; Daniels, 2009; Rajala et al., 2016), the interview question encouraged the teachers to reflect holistically on their pedagogy. The interviews began with the following open-ended questions: When you started using FL, what problems did you try to solve by changing your teaching approach? What are the features in the current learning culture that you are satisfied with? What are you dissatisfied with? What do you not want to give up for the sake of yourself or for the students? Before the interviews, we asked all participants if they thought the definition of FL was in line with their own teaching views. Three of them (Mark, Mary, and Peter) self-identified as advocates of the FL approach, but not as advocates of FC. Jack self-identified as an advocate of both FL and FC.

In this research, we followed the ethical standards for scholarly research promulgated by the University of Helsinki and the Finnish National Board on Research Integrity. The teachers participated on a voluntary basis, and all gave informed consent. All names are pseudonyms.

Analysis

The interview data analysis was informed by a grounded theory (GT) approach (Corbin & Strauss, 2008; Suddaby, 2006). GT was an appropriate approach to guide the data analysis in our case because our intention was to understand FL, as much as possible, from the teachers' perspectives. In particular, we adopted Corbin and Strauss's (2008) inductive GT approach for data analysis and coding (open coding, axial coding, selective coding). However, we did not use GT as a research methodology to explore the unknown, to include theoretical sampling and constant comparison where data are collected and analysed simultaneously, and to focus a theory building (see, e.g. Suddaby, 2006). The grounded analysis process involved individual and group readings of the data. Research team members shared their interpretations during reflective discussions. The data were then revisited in the light of these discussions.

Although the conversational open-ended interview approach and its lack of structure are seen here as beneficial, the inconsistency of interview questions posed a challenge to data coding (see, Turner, 2010). To meet this challenge, we used the following sensitising questions to lift the raw data to a conceptual level: (1) broader pedagogical goals and objectives (Why?); (2) tools and study materials, and their use (How?); (3) practices of control and discipline (How?); (4) evaluation practices (How?); and (5) what is valued as learning mathematics (What?) (See also, Engeström, 2001). The aim of the questions was to find relevant extracts which could be analysed. We sought to learn how the teachers describe pedagogical judgments and deliberations in response to complex demands they had experienced with FL in several years of practice.

The open and axial coding phases of analysis addressed the first research question: What pedagogical rationales, practices, and tools can be identified in the teachers' accounts of FL? As an example of the open and axial coding analysis phases, we used the following extract from Jack to a "Why?" question.

> FL was a solution to the problem: I needed more time to do the exercises. I wanted the classroom time to serve the students more effectively. The students, especially in upper secondary school, did not benefit 100% from the lessons.

This data segment was labelled in the open coding phase with three concepts: "effective classroom time", "benefit from teacher presence", and "students' activity". In the axial coding phase, the emerging categories and their subcategories were either classified as pedagogical rationales or practices and tools and further re-examined by focusing on their relationships with one another as a purpose to attach developing categories to each other in a theoretically meaningful way. In Jack's excerpt about the axial coding phase the "effective classroom time" concept was raised to a category that illuminates one of the pedagogical rationales of FL. The "students' activity" concept was included within the "effective classroom time" category. The "benefit from teacher presence" concept was connected with the pedagogical practice called "individual teacher guidance".

Table 1 presents the results of the open and axial analysis phases in terms of preliminary categories of pedagogical rationales and related practices and tools. The table also shows representative data excerpts. For example, how to respond to heterogeneity was linked to practices such as abandonment of a common lesson, differentiation through learning materials, and individual teacher guidance. The order of presenting the rationales is related to the results of the next selective analysis phase.

In the selective coding phase, we tested possible core categories which could explain or convey the teachers' pedagogical interpretations of FL "theoretically". In other words, the pedagogical rationales, practices, and tools formed by teachers' subjective experiences were re-evaluated and abstracted into theoretical statements about FL in mathematics. The results suggest there are three core categories (main rationales) that embody FL as a pedagogical approach. These categories are *Individualising Learning, Fostering Self-regulated Learning*, and *Fostering Engagement*. The categories wrapped around the teachers' aspiration to encounter students as individuals. Although there are no clear boundaries between the main rationales, and they partially overlap, the subdivision illustrated in Figure 1 can still be implemented. The concise descriptions of these three main rationales and examples of their occurrence in the research data are presented in Table 2 in the result section.

Research results

The study reveals three main pedagogical rationales in the teachers' accounts that embody the pedagogy of FL in mathematics, namely *Individualising Learning, Fostering Self-regulated Learning*, and *Fostering Engagement* (see Table 2). Next, we discuss each of these pedagogical rationales in more detail and give examples about practices and tools that we identified in the FL teachers' accounts as related to the rationale in question. Teacher informants are compared to each other only in situations where some distinct variations were observed.

Table 1. Pedagogical rationales formed in open and axial coding phases and examples of their occurrence in practices and tools.

Pedagogical rationales	Practices and tools	Excerpts
Responding to heterogeneity	Abandon of a common lesson, Differentiation through learning materials, Individual teacher guidance	Mark: "The weakest students seem to benefit from this system, but the advanced ones benefit even more. The gap between these two is growing."
Making learning more effective	More exercises in class, detecting problems, Rearranging teachers' class time, Student individual support	Jack: "It was a solution, especially at the upper secondary school, to get more time for exercises at school. I wanted the hours at school to be more effective."
Increasing humanity in learning	Structures that withstand momentary inefficiency, Taking into the account students' various needs	Mark: "If that worst moment comes at the beginning of the week, then it needs to be caught up at the end of the week."
Improving circumstances for students' autonomy in learning	Self-paced study, Student-based differentiation, Strengthening sense of control and responsibility, Timetable reorganisation, Physical learning space reorganisation	Mark: "Students differentiate the learning themselves. At the same time, they have a clear picture about what they are aiming for."
Supporting goal directed behaviour	Clear instructions for learning, The connection between learning material and assessment	Mark: "In everything we try to make a path visible, what is there to achieve the advanced level of learning and the minimum level of learning."
Fostering self-determination in learning	Self-assessment	Peter: "The students are not used to self-evaluate their own learning and making the decision that 'now I master the subject'. Instead, they are used to trust that the teacher decides this."
Strengthening self-awareness	Identification of own resources	Mark: "If a student recognises their own resources – I will now spend less time on this, so I can spend more time on that – is an excellent thing."
Reinforces students' sense of mathematical ability	Self-study, Strengthening self-esteem	Mary: "It is not a bad thing that the students learn to read the textbook by themselves and to understand what they have read. Instead of always waiting for there to be someone else to tell them how to think mathematically before they can do something, they are encouraged to trust their own ability to learn."
Engagement support	Behavioural activity support, Emotional support, Support for working collaboratively with the teacher.	Mark: "I ask them to comment a lot. Or, if I plan something, I ask, how would you want to do it.

Individualising learning as a pedagogical rationale in FL

Individualising Learning rationale addresses the teachers' need to differentiate learning. The rationale emphasises a holistic view of learning. It is related to teaching mathematics as an attempt to humanise learning of mathematics in heterogeneous student groups, not the mathematics learning per se. This is especially evident in Peter's statement.

Excerpt 1

> Peter: During the last few years, the purpose has also been to form students as human beings. At the beginning, I thought of this development only from the point of view of mathematics, but now I think of mathematics as a by-product in growing as human beings: learning to learn and learning cooperative skills. Moreover, I try to arrange the learning with the help of mathematics

contents, but at the same time, I try to think about higher-order thinking based on Bloom's taxonomy. In addition to remembering, understanding, and adapting, I am interested in how students learn to analyse not only the subject, but also their own learning processes.

The pedagogical rationale called Individualising Learning sees students as individuals and places them in the centre of learning. Students are active participants guided by practices and tools with the objective to master the learning. The teachers' view about "towards mastery" were also supported by Bergmann and Sams (2012). They suggested using the

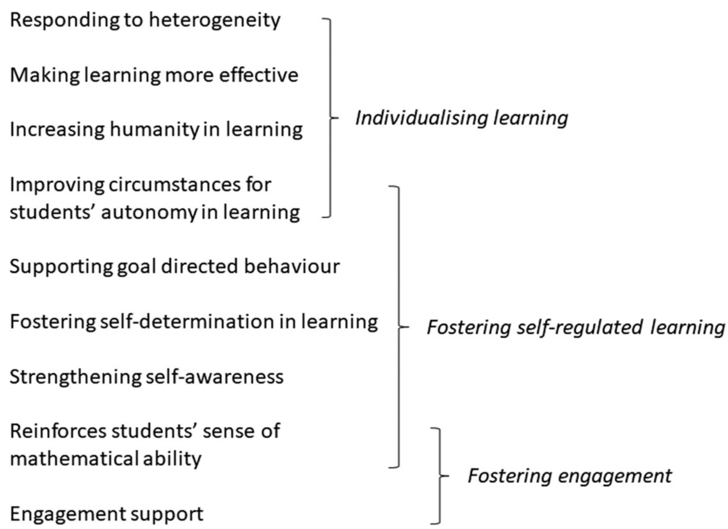

Figure 1. Three core categories (main pedagogical rationales) in the selective coding phase and their connection to nine pedagogical rationales.

Table 2. The main pedagogical rationales that embody FL as a pedagogical approach.

Main pedagogical rationales	Definitions	Excerpts
Individualising Learning	Individualising Learning rationale emphasises a holistic view of learning and an attempt to differentiate and humanise the learning of mathematics in heterogeneous groups of students.	Peter: At the beginning, I approached development only from the point of view of mathematics, but now I think of mathematics as a by-product of the growth of human beings: learning to learn and learning cooperative skills.
Fostering Self-regulated Learning	Fostering Self-regulated Learning rationale emphasises self-regulation as an objective for education, and not just as a means of education. In this rationale students' control is restricted to the learning activity. The teacher controls the learning trajectory as an entity.	Peter: We try to automate some ways of doing things. Students try to work without the teacher as long as possible so that when they need support, the teacher will have enough time to focus on that student or small group.
Fostering Engagement	Fostering Engagement rationale directs attention not only to students' volitional capacity to act in a learning environment prepared for them but also fosters students to work collaboratively with their teachers to create a personally more motivationally supportive learning environment.	Mark: I ask them a lot of comments on all this. Or, if I plan something to do, I ask how they want to do it.

idea of the "flipped-mastery model" instead of FC even before the idea of FL was proposed. In our view, some clarifications are required about what "towards mastery" means for the teachers in this study. In the context of this study, the principles for Mastery Learning (see, Bloom, 1968; Keller, 1968; Kulik et al., 1990) were manifested in the mathematical learning paths when the material to be learned is divided into short units. These units end with small tests to be completed before students can progress to the next unit. However, the idea of time and progression was not observed here as in Bloom's view of mastery in learning. In Bloom's view, mastery learning is referred to situations in which the students move through the units at a uniform teacher-controlled pace. If there are any learning gaps, teachers dedicate additional time and support to fill the gaps. The premise is to control that all students proceed to the next unit with the teacher. This does not seem to be the case in this study. The teachers' views collected in this study seem to align with Keller's (1968) view of mastery learning. He has described it as a Personalised System of Instruction. Similar to the view of Keller, the units to be learnt are presented with the material, which students go through by themselves at their own rate, instead of going through the material with the teacher. As Mary said in the next excerpt, self-paced learning in FL means that students can use all the time spent in the mathematics classroom to master certain mathematics subjects that embody their individual objectives in mathematics learning.

Excerpt 2

Interviewer: What are you satisfied with in your current learning culture?

Mary: One big relief is that fewer courses remain hanging for days. I don't need to give a level four grade to anyone or be worried about what we should do to get these students to pass the course. There is no doubt that I can give at least the grade five to anyone who takes part in common teaching because they can use all the time to reach this level. There is no need for the lowest grade. Further, when they find the motivation, students will be able to rush forward. For example, if a student has done poorly during class number seven, but in class eight he or she finally finds the drive to study, he or she may learn two years' content in a couple of months. It is great that no one needs to be afraid of falling behind. It is always possible to speed up and study what is needed to complete a comprehensive school curriculum.

Based on the teachers' experiences FL does not seem to give uniformly high-performance results in mathematics for all as Bloom's (1968) mastery learning supposes. In Individualising Learning, the teachers seek attitudinal gains, and they try to promote achievement but as Mark emphatically states, not all students reach a high level of mathematical competence.

Excerpt 3

Mark: In my opinion, this method does not improve learning outcomes. The learning outcomes are pretty much the same. If learning outcomes improve, that is because of some students become more motivated in the process. So, learning outcomes may improve a little, but not in a way that everyone's learning outcomes would improve, no, not at all.

The Individualising Learning rationale becomes clear when the teachers do not seek to set the same content requirements for all, because this would lead to challenges and tensions in practice. The competence difference between more- and less-able students might be huge. The teachers consider it useless to fight against this difference, so they accept it as a condition. The findings suggest that the teachers' primary objective is not to reduce the skills gap between students, but rather to focus on students as individuals and support them to achieve their best (see Mark's excerpt in Table 1). For them, there is no ceiling on the level of learning.

Fostering self-regulated learning as a pedagogical rationale in FL

It is not surprising that self-regulation is mentioned in one way or another in this study since one of the biggest concerns in implementing FL in mathematics education is the lack of students' self-regulation (Cheng et al., 2019; Lai & Hwang, 2016; Mason et al., 2013). However, in our data, none of the teachers considered self-regulation to be a mere means of education but rather as an educational objective. Although practices and tools presented in FL guide students to self-regulate, the teachers are aware that some students lack self-regulation capacity as Mary states:

Excerpt 4

> Mary: Self-regulation depends on students, and on situations. Some will accept responsibility for their learning, others won't.

In this statement, Mary connects self-regulation with bearing the responsibility for learning manifested in students' actions along mathematical learning paths. The pedagogical tools that the teachers choose and use to promote self-regulation in practice are lists of exercises called mathematical learning paths. These paths express in a clear manner the minimum level of activity and different learning levels. Mathematical learning paths were used to help students to adjust and set their own learning goals, to develop control over their own learning, and to meet competence requirements.

Excerpt 5

> Mark: We try to make a path visible, what must be achieved at the advanced level and at the minimum level of learning. Between these levels students adjust what they are doing. Another issue in the material is that students differentiate their learning themselves, and at the same time, they have a clear picture about what they are aiming for. In principle, the assessment is ready when the work is done. In the end, we just judge whether you achieved the goals you were striving for.

As a pedagogical practice associated with mathematical learning paths, the teachers considered self-paced learning significant. Self-paced learning sets students free to decide themselves how to use the time during the class for learning. For example, Mark refers to a situation in which a student puts the headphones on and participates in a private learning session in the classroom.

Excerpt 6

> Interviewer: Did you like teacher-led lessons?
>
> Mark: No, it's not fun to try to ask students to concentrate if it's something that is not natural for everyone. If they paid 100% attention while you are speaking, then why not. I would like to talk all day but if you need to ask for attention, the fault is somewhere other than with the students. When they just can't do it, it's no use trying to explain it. Preferably put the headphones on and watch a video if you can concentrate better than forced to listen to me with the others in the class.

In general, FL studies demonstrate problems in students' individual learning moments at home due to the lack of students' self-regulation. The situation described by Mark (Excerpt 6) differs from this significantly. He allows students to watch and learn from the videos either at home or school depending on each student's choice. Apart from Mark's comment, no other teacher mentioned in the interviews that a student's individual learning space should be outside the school setting. Furthermore, as Mark's next passage illustrates, it is essential to accept that there are better and worse learning days, and students take responsibility for their own learning. When this is understood, teachers can support self-regulation.

Excerpt 7

> Mark: When you have one week to complete the tasks, it does not matter if you have bad moments, then studying doesn't benefit you. If that worst moment appears at the beginning of the week, then learning must be caught up by the end of the week.

Considering the findings illustrated in excerpts 4 to 7, the pedagogical rationale under discussion was on *fostering self-regulated learning* (SRL) and not fostering self-directed learning (SDL). According to Zimmerman (1989), definitions of SRL assumes the importance of three elements: students' self-regulated learning strategies, self-efficacy perceptions of performance skills, and commitment to academic goals. SRL is seen as a goal-oriented activity. Students set goals for the learning and try to monitor, regulate, and control their cognition, motivation, and behaviour constrained and guided by their goals (Pintrich, 2000; Zimmerman & Schunk, 2011). The conceptual foundation of SDL is similar to SRL. SDL describes a process in which students take the initiative to diagnose their learning needs, formulate goals for learning, identify learning resources, implement appropriate learning strategies, and evaluate learning outcomes (Knowles, 1975). Both SRL and SDL involve students' active engagement and goal-directed behaviour. Thus, they address responsibility issues and control in learning (Loyens et al., 2008; Pilling-Cormick & Garrison, 2007). But there is a significant difference between these two: a "self-directed learner controls the learning trajectory as a whole, whereas a self-regulated learner's control is restricted to learning activity" (Cosnefroy & Carré, 2014, p. 4).

In relation to teaching mathematics, SRL refers to holistic learning objectives, not mathematics learning objectives. Self-regulation as a pedagogical rationale in this study focuses on completing a task, not directly on purposes of mathematics learning. Thus, the conceptual knowledge of mathematics depends on the tools used in FL. The study reveals differences not only among the tools the teachers prefer but also in how they are supposed to be used. The following extracts from Mark and Jack talk about the importance of videos in learning mathematics.

Excerpt 8

> Interviewer: Are students required to watch videos, or is it optional?
>
> Mark: Required, but there is no way I can control whether they watch them or not. For example, I refuse to advise a student if he or she has not watched the video. Because I am appealing to you that if I tell you that broadening means that you multiply the numerator and the denominator in that number and if you do not know what a numerator and denominator are, why would I bother to advise you? You must watch that video. You need to know what we are talking about here and then I will give you advice.

Excerpt 9

> Interviewer: Is there something in your current actions that you do not want to give up?
>
> Jack: I don't want to give up videos, because students need to learn the theory from somewhere. They need to reach an adequate level of abstraction to get to a sufficient level of proficiency in mathematics. In my opinion that it won't rise high enough if they just do assignments and try to look at examples from the book.

Unlike Jack and Mark, Mary and Peter prefer textbooks. They have not prepared learning videos themselves, but their students have the option to use those available online. According to both teachers, using videos has not been actively promoted. Mary uses textbooks as a learning material. She emphasises the importance of reading theories first. However, Peter values students' decisions to use learning materials in the best suitable way for them. He does not seem to agree with others that you need theories. In future, he wants to create a system where tests guide learning and not the other way around.

Excerpt 10

> Peter: Traditionally, students practise first, then they have a test afterwards. Next autumn we will change it the other way round. When students come to school, I will give them the 8th grade test to do. They can do it right away with a computer and verify themselves whether they have mastered the subject or not. They will see how the system works and they will practise a little to analyse the problem with easy examples. They will learn to evaluate. It's difficult for students to decide whether they are competent in the subject matter if the teacher doesn't say it aloud. We will try to activate students' self-confidence. If they pass the test, they can do the next level test without doing the exercises of that level. They will try to manage without the teacher until they can't pass the test. When they don't pass it, the teacher will step in and give some exercises or provide personal tutoring. We will try to automate some ways. Students will try to work without a teacher for as long as possible so that when they need support, the teacher will have enough time to focus on that student or on a small group. Plus, efforts have been made to automate thinking so that students will get the experience of a certain responsibility and autonomy.

The teachers' views on responsibility and trust are connected to the practices that they prefer. They are also related to the experience of how much control would be needed in what students are doing. If we look at how Mark sees the control in excerpts 2 and 9, it has changed in its form. Previously, when he was teaching, Mark had to control students' behaviour so that he could teach. In FL, Mark controls classroom events that help students become self-regulated learners who monitor their activity in class themselves. It is worth noting that Mark does not assume that students should control the learning trajectory as an entity, just the learning activity. On the other hand, Peter would favour more of a student's autonomous regulation as a degree of control. From here, we can see that one favours an autonomous SR (Peter) while another (Mark) favours a more controlled SR (see e.g. Cosnefroy & Carré, 2014; Deci & Ryan, 2002). For Peter, there is trust in students, and SRL supports the view that students are responsible for their own actions. Mark thinks that students have to earn his trust.

Excerpt 11

> Mark: The first thing for students to learn is that if I give them something to do, they must do it. I wouldn't want to control anyone, but I must until the trust is achieved. I refuse to use any electronic material that does not give me any information about completed assignments by students.

Mark seems to use coercion to direct students to behave like a self-regulated learner. For him, one important reason for using digital learning tools is that he can check anytime and make sure that students have done what they were tasked to do. He stated that without such tools there would not be enough time to keep track of what is going on in class.

Fostering engagement as a pedagogical rationale in FL

Fostering Engagement is a pedagogical rationale which directs attention towards the students' volition in the learning process and their commitment to academic goals. While motivation refers to students' intention (will), engagement here is related to students' effort (skill) to keep themselves on track and completing a task (Wang & Degol, 2014). In the next excerpt, Mary illustrated her struggling particularly with low attainers and the reasons for students' poor learning skills when learning as a class.

Excerpt 12

> Mary: I didn't know what to do with the group. It was so heterogeneous. The class had some terrible discipline problems, there were problems in school attendance and in mathematics skills. I was alone with these problems, and I felt I had to do something different. I already knew the group from the seventh grade. I know that it was impossible to hear my voice in the class. That was frustrating for everyone.

Here, the Fostering Engagement rationale embodies the teacher's aspiration to support students to act in the learning environment prepared for them, to grasp the tools that initiate and support learning mathematics, to overcome their frustration, and to help students believe in themselves as learners of mathematics. The behavioural, cognitive, and emotional forms of engagement (see e.g. Fredricks, Blumenfeld, & Paris, 2004; Wang & Degol, 2014) also become evident in the teacher's attempts in fostering SRL. However, the reason Fostering Engagement was raised as a pedagogical rationale is not based on these three typical forms of engagement (see e.g. Archambault, Janosz, Morizot, & Pagani, 2009;

van Uden, Ritzen, & Pieters, 2013). Instead, the fourth form of engagement is embodied in the next excerpt by Mark, when he asked students to contribute to his actions and have an influence in motivation.

Excerpt 13

> Interviewer: What role do your students have in what you do as a teacher?
>
> Mark: I ask them to comment a lot. Or, if I plan something, I ask how do you want to do it? Would you like to use pen and paper or a computer? I often leave the option for them to choose whatever they want. Because they use those tools that they think are the best ones. I don't like the idea that a school principal would come to me and force me to use certain tools.

Reeve and Tseng (2011) call this form of engagement "agentic engagement". It is meaningfully different from the three other types of engagement listed above. The previously mentioned three types of engagements focus on students' reactions to classroom experiences. Agentic engagement reflects students' direct and intentional attempts to enrich the learning process by actively influencing teacher's actions (Reeve & Lee, 2014; Reeve & Tseng, 2011; Wang & Degol, 2014). As Reeve (2013) states: "Behaviourally and cognitively engaged students may attend, emulate, and internalise their teachers' tutoring and scaffolding, but agentically engaged students uniquely try to collaborate with teachers to create a personally more motivating and supportive learning environment."

Mark has challenged the learning structures and timetables to increase the control students have in their own learning and to create practices to enable student control. To this end he has divided primary school subjects into "weekly project subjects", which cover all subjects taught by the teacher (excluding music, visual arts, physical education, handicrafts and optional subjects). He lets students decide what subject they study, when and how extensively.

Excerpt 14

> Mark: It is just okay for me if a student shows that he or she has completed the minimum level of mathematics and is not going to do more. Fine. Thank you. Go ahead.
>
> Interviewer: In these situations, are you disappointed with yourself as a teacher?
>
> Mark: No, because students usually say that they want to become better in English, for instance, and they invest in it. This is such a sensible opinion from a child of that age. After all, we all act within our resources.
>
> Interviewer: It is great that you accept their decision.
>
> Mark: Yes, it is. I know that whenever I say this aloud there are teachers who would shoot me down. If you would ask this of all teachers in Finland, they would comment that you cannot say so. I will still say so. If a student identifies his or her own resources and decides to spend less time on this and more on that, that is a great thing. No one can assume that you should spend this much on this and that much on that.

As this extract shows, students are encouraged to make both activity-related and content-related choices following their own engagement.

According to Mark one of the basic life skills is to learn how to organise the time available for learning. Some students are happy to learn only the minimum amount in some subjects so that they have time to put more effort in other subjects. Mark mentions in extract 15 that the time and effort should be valued, because if students have time to develop the skills which are important for them as individuals, it connects to their self-esteem and increases positive feelings about learning at school.

Excerpt 15

> Mark: There is something interesting about self-assessment. For example, when a student gives himself or herself a grade seven, he or she is happy with it. They see it as this is what I have earned, this is how much work I have done. It is like a statement. . . . If the teacher evaluates a student, it has a different effect on students' self-esteem. Then, a child or young person builds the identity based on teacher's assessments and not on their own assessment. In these situations, you need to succeed at a high level so that you can be self-confident. If you don't succeed, it's hard to see yourself in a good light.

Similarly, the next excerpt from Peter shows how FL teachers outsource some unpleasant activities that are typically considered to be a teacher's responsibility. Peter states that if students are treated as human beings, in the long run they will also start to do purposeful work in mathematics.

Excerpt 16

> Interviewer: Who determines what students should do in class?
>
> Peter: Students themselves. I really try to act in a way that I allow my class everything. If I find out that . . . this is exactly what has happened. If I see someone writing an essay in Swedish, then I ask may I help you with that essay. Then we might discuss it for a moment. . . . I have noticed in practice that I never need to tell them that they should do something. If they are treated as human beings or can be humanely treated, at some point they will automatically start to do purposeful work. . . . I always try to think that if someone acts differently from what I'd hoped, he or she has some human reason for doing so. I have no right to disapprove of anyone's actions. If I asked the person does something else, I think it would do more harm than good for our relationship. I would rather ask if I can help with what they are doing. This way I try to direct or manipulate actions. Should you do a little bit of mathematics, or would you like to continue what you are doing? They do have such assumptions that mathematics should be done in the mathematics class. That assumption adequately guides their actions. I don't have to be the one who controls.

Discussion and conclusion

This study contributes to the emerging line of research in FL. Its purpose has been to provide a better understanding of teachers' pedagogical rationales, practices, and tools when using FL in teaching mathematics. The first research question of this study asked: What pedagogical rationales, practices, and tools can be identified in four FL mathematics teachers' accounts of FL? Our findings reveal three main pedagogical rationales for the teachers' use of FL, namely Individualising Learning, Fostering Self-regulated learning, and Fostering Engagement. The Individualising Learning rationale addresses the teachers' need to differentiate learning and is related to teaching mathematics as an attempt to humanise learning mathematics in heterogeneous student groups. Fostering Self-regulated Learning rationale emphasises self-regulation as an objective for education, and not just as a means of education. The Fostering Engagement rationale embodies the teacher's aspiration to support students to act in the learning environment prepared for them, to grasp the tools that initiate and support learning mathematics, to overcome their frustration, and to help students believe in themselves as learners of mathematics.

Our findings also shed light on the practices and tools of the teachers for achieving the three pedagogical rationales. Central to their FL practice was the idea of self-paced learning supported by mathematics learning paths. For the teachers, mathematical learning paths are tools which guide students' activities step by step to read theory, to watch videos, to do exercises at different learning levels, and to take a self-assessment test at the end of the learning path in question. On one hand, the teachers suggested that mathematical learning paths can help students to adjust and set their own learning goals, to develop control over their own learning, and to meet competence requirements. On the other hand, they thought that mathematical learning paths can build a framework for students' self-regulation while creating opportunities for teachers to work with and support those students who have problems in learning mathematics or in directing their activity toward learning.

Overall, the findings from the first research question demonstrate that the teachers considered FL as a pedagogical approach suitable for all students, and not only for those students who can be described as "advanced self-regulated learners", as suggested in some other studies (e.g. Lo & Hew, 2017; Mason et al., 2013). In the four teachers' accounts of their FL practice, students' self-regulation and engagement with mathematics in FL largely relied on students' freedom to complete appropriate levels of exercises at their own pace and to take self-assessment tests at appropriate intervals. Although the activity can be seen as a shared control in which a teacher first chooses several possible learning exercises and learners will then choose tasks from this selection and begin to study (see, Kirschner & van Merriënboer, 2013), two concerns supported by previous research still emerge. First, a student might work effectively in the classroom and complete assignments but without learning anything. Kirschner et al. (2006) have warned that just searching for ways to get the tasks solved does not support deep learning in mathematics. This may occur if learning mathematics is just seen as completing tasks. Second, if the self-assessment tests are used to measure students' achievements based on how they imitate previous practices, the exam does not support the learning of mathematics in sustained and meaningful ways (Shepard, 2005).

The second research question in this study addressed the relationship between the teachers' pedagogical FL rationales and teaching of mathematics. Our findings related to this research question were somewhat surprising; all the pedagogical rationales found in the study were related to general learning goals, and none of them specifically concentrated on learning mathematics. In this study, there was a lack of reflection on FL and mathematics learning. Although the FL teachers had developed a rich repertoire of ways to support their students learning in general, less attention was given to considering how FL supported students conceptual understanding of mathematics and developed mathematical skills and knowledge that can be transferred to new contexts (see e.g. Kilpatrick, 2014; Niss & Jablonka, 2014; Shepard, 2005). In the light of these findings, it is appropriate to ask whether the teachers' pedagogical expertise supersedes subject matter expertise in FL.

This study points out the need for further research on FL, including the following two questions: Why is learning reversed at the practical level? What is reversed in relation to what? Moreover, the underlying pedagogical rationales behind teachers' practices and tools used are crucial in attempts to understand FL. It is essential to understand how teachers make sense of FL and what they add to FL practices and tools as part of broader teaching goals, not so much the new practices and tools in FL themselves. More research would also be welcome to understand what kind of mathematics learning FL supports.

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