Bill's Rationales for Learning Mathematics in Prison

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To cite this article: Linda Marie Ahl & Ola Helenius (2020): Bill's Rationales for Learning Mathematics in Prison, Scandinavian Journal of Educational Research, DOI: 10.1080/00313831.2020.1739133

To link to this article: https://doi.org/10.1080/00313831.2020.1739133

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Published online: 12 Mar 2020.

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ABSTRACT
This paper reports on a case study of a student’s rationales for learning mathematics. We operationalize Stieg Mellin-Olsen’s educational concept of rationales for learning and apply the concept on data consisting of three semi-structured interviews with a student in the Swedish prison education program. Our analysis shows that the student’s rationales vary in character over time as a reaction to his educational contexts. We conclude that Mellin-Olsen’s construct of rationales is useful for understanding students’ changing motivation in relation to the teaching and to the practice of mathematics the teaching entails. Teachers may use the concepts from our analysis as cognitive tools, related to students’ different rationales, opportunities arise for an individualized instructional design.

ARTICLE HISTORY
Received 15 June 2019
Accepted 11 February 2020

KEYWORDS
Individualized instruction; motivation; rationales; prison education

Introduction
If only the students could be more engaged and motivated! This was a common response from teachers in Sweden in a large-scale classroom study about a decade ago. Teachers were worried about low student achievement and about students not learning what they should. An underlying assumption seemed to be that students would learn more if they were more engaged and motivated. The idea that students’ lack of motivation and engagement is a problem is not unique to Swedish teachers. Similar assumptions have made research on motivation one of the cornerstones of educational psychology for over half a century (Graham & Weiner, 1996). The interest in traits like mindset (Dweck, 2006, 2016) or grit (Duckworth, 2019; Duckworth et al., 2007) shows that the quest for understanding what makes students engage and persevere in following educational goals is as active a subject as ever.

A surface component of students’ engagement was actually measured in the classroom study mentioned above. The researchers estimated the proportion of students that were actually doing what they had been instructed by the teachers to do. This was done five minutes into the lesson, five minutes before the end of the lesson as well as in the middle of the lesson. The numbers typically came in at above 95% – a very high number. So even though the students did not display the type of engagement that their teachers were hoping for, they were at least motivated enough to do what the teacher instructed them to.

The view implicit in the worries of the teachers coincide with the general view championed in psychological research on motivation. Here, the unit of analysis is normally the individual and...
her interpretation of her role in the educational context given (Graham & Weiner, 1996). Rarely is this context analysed with respect to the presentation of the mathematics in relation to the students’ views and needs (Hannula, 2006). Doing so would mean complementing the typical psychological perspective normally adopted when studying motivation with a social perspective looking at the student and her environment as well as with a pedagogical perspective dealing with the presentation of the subject itself. It is such a framework we seek to explore in this paper.

A research framework shall always be determined in the light of the questions you seek to answer and the context within which you conduct your research. In this paper, we deal with motivation in a rather special social context, namely mathematics education in prison. Prisoners in Sweden that lack an upper secondary school diploma are offered education that follows the same curriculum as regular schooling. The practice is organized as individualized instruction (c.f. tutoring). Since prisoners volunteer for education, a certain amount of initial motivation is present. But the vast majority have bad experiences from previous schooling and in particular from school mathematics, which makes their motivation fragile (Ahl et al., 2017). This motivational fragility can be handled through carefully chosen instructional activities that fit the student’s potential for engaging in mathematics learning. However, the opportunity to individualize instruction calls for information about both the student’s prior knowledge and the nature of his driving forces for studying mathematics. In this paper we deal with the latter, namely how you can frame students’ motivations so instruction can be adjusted accordingly. To investigate this motivational issue, we needed a conceptual frame suited to this context (Lester, 2005). In the following section, we will briefly describe some major theories from research on motivation before arguing for the conceptual notions of rationales for learning by Mellin-Olsen (1981) as suitable for our aim.

Individuals’ Driving Forces for Engaging in Learning

The question of what drives individuals to engage in learning has been studied extensively in the research field of motivation. The fundamental role of education in society explains why, at least since the seventies, it is in educational psychology that most of the motivation research has been carried out (Graham & Weiner, 1996). Mainly, motivation is used by researchers as a lens to study students’ mathematical behaviour (Durksen et al., 2017; Hannula, 2006). This lens embraces a plethora of concepts such as affect, emotions, goals, needs, beliefs, views and values. This variety of concepts provides several possible approaches for research. Examples include Self-efficacy theory (Bandura, 1977, 1997) that deals with the individual’s beliefs concerning how successful he might be in handling the task, and expectancy-value theory ( Wigfield & Eccles, 2000) which deals with how important the individual thinks the task is. As is typical for theories of motivation, these two theories try to explain how the level of motivation is affected by fine structures in the relation between the task, the context in which it is given and the individual (Pajares & Graham, 1999). In similar ways, attribution theory deals with motivational effects of what the individual attribute the causes of success or failure to (Weiner, 2000). The mentioned theories are similar in the sense that students’ levels of motivation are described as dependent on a particular factor in how the student sees herself in relation to the educational environment.

A different approach is given by self-determination theory (Deci & Ryan, 1985; Ryan & Deci, 2000) which in contrast to the above-mentioned theories is a macro theory that concerns motivation on a broad level. Self-determination theory builds on the dichotomy of intrinsic and extrinsic motivation. Individuals’ engagement is studied from the premise that a task can either be inherently motivating (intrinsically motivating) or a task can be motivating because it leads to some desirable outcome, separable from the activity itself (extrinsically motivating). Innate needs for autonomy, competence and relatedness have been shown to be driving forces of intrinsic motivation. Since intrinsic motivation leads to high quality learning and creativity, conditions stimulating intrinsic motivation have been given a lot of attention. However, since intrinsic motivation is often elusive, extrinsic motivation too has been analysed. In current theorization, extrinsic motivation is described,
as a continuum ranging from externally regulated to integrated, where the latter is considered more desirable. Like with intrinsic motivation, factors that could facilitate or undermine internalized extrinsic motivation have been studied extensively and factors like relatedness and competence re-appear here (Ryan & Deci, 2000).

Research on motivational has explained how motivation can differ in character and level, and provided a lot of details on how individuals need to perceive a situation for it to become motivating. But, as Schukajlow et al. (2017) conclude in their review of motivational research, there are very few intervention studies targeting student motivation for mathematics learning. We see two possible reasons. Students’ motivational structures might differ quite a lot. Self-efficacy might be a dominating driver for motivation for some while the valuing of tasks or how efficacy is attributed might be more important drivers for others. As described by Hannula (2006), also within an individual the structure of goals and needs can contain conflicts. Catering for a broad spectrum of contextual variables that influence motivation creates a need for dealing with several theoretical constructs at once. This makes applications of theories of motivation complicated when designing interventions. The second reason pertains to that teaching that fosters competence, autonomy and relatedness, which are driving forces of desirable types of motivation, already are relative commonplace aims for modern mathematics teaching even when motivation is not explicitly dealt with. Yet, the relationship between mathematics as a socially constructed field and the students’ desire to achieve has not sufficiently been explored (Middleton & Spanias, 1999). Furthermore, in a recent review it was concluded that there is still a lack of studies that integrate research on motivation with theories from mathematics education (Schukajlow et al., 2017).

A common denominator for the above-mentioned theories is that they try to answer how to get the students to accept the basic principle for schooling and mastery of the material presented by the teacher (Graham & Weiner, 1996). For large scale instruction, this is indeed an important premise because it is not possible to cater for the need of every student individually. However, in individualized instruction the teacher or tutor have opportunities to adapt the teaching to each student. This opportunity is our motivation for looking at the work of Stieg Mellin-Olsen who said

If the roots of the failure in learning are buried in a curriculum which is of no interest to the learner, a strategy of instruction like the one indicated above [same curriculum, our remark] may aggravate the pupils learning problems. It may promote the rationale which is already working which tells the pupil it does not pay to learn this kind of subject matter. (Mellin-Olsen, 1981, p. 160)

Mellin-Olsen (1981) understood quality in education in terms of its social consequences. The necessity of designing a teaching practice that took into account the social and political dimensions as well as theories of teaching and learning was the focus of Mellin-Olsen’s lifelong contribution. He claimed that education needs to address the students’ sociologically distributed rationales for learning, as well as their rationales grounded in a wish for the formal qualification, necessary to enter the next level in the educational system (Mellin-Olsen, 1981). Following Mellin-Olsen’s philosophy on quality in education, we will propose a way of examining students’ rationales for learning. Our hypothesis is that constructs from his work can provide teachers with an applicable cognitive tool that can be used for planning instruction in line with the students’ goals and needs, in the very special context of individualized instruction in the Swedish prison education program.

Students’ backgrounds, personal histories and future outlook can be very diverse in the Swedish prison education program. This diversity is reflected in a diversity of rationale for studying mathematics. Hence, to be able to individualize instruction we need a way to capture different students’ rationales. The question guiding this study is: How can we characterize students’ motivation for studying mathematics in relation to their social context, by means of Mellin-Olsen’s concepts S-rationale and I-rationale? We examine this question by displaying one single case that can serve as an existence proof of the concept of operationalizing Mellin-Olsen’s concept of rationales. The purpose of this paper is hence to investigate if it is possible to describe a student’s rationales with Mellin-Olsen’s educational concepts for learning: the sociological S-rationale, and the instrumental
I-rationale (to be further explained in the next section). While Mellin-Olsens work is still frequently cited, few researchers have put his work to use by operationalizing it methodologically. Besides a few short conference papers, the few exceptions we have found include Goodchild (1997), who examines rationales in a grade 10 class over one year with ethnographic methods, and Rensaa (2014), who uses the development of students’ rationales for evaluating an intervention in engineering degree mathematics. The novelty of our approach consists of operationalizing Mellin-Olsens rationales to analyse students’ mathematical experience through interview data.

**Theoretical Framework**

In 1981 Mellin-Olsen published a paper where he questions the scope of the psychological concepts of instrumental and relational understanding. He stressed that the usual distinction between instrumental and relational understanding was insufficient to interpret learning in an educational context. When Mellin-Olsen (1981, 1987) elaborates on the concepts, from a socio-political perspective, he introduces instrumentalism as a deeper educational meta-concept. Instrumentalism is defined as a rationale for learning, connected to the role school has as an instrument for the individuals’ future possibilities for higher education and employment. Two different rationales for learning emerge from instrumentalism; the sociological S-rationale and the I-rationale, representing the reproduction of ideology, culture and the reproductive forces in society. He explains the S-rationale for learning as follows:

This rationale for school learning I have called the S-rationale to indicate its social importance. It is the rationale for learning evoked in the pupil by a synthesis of his self-concept, his cognition of school and schooling, and his concept of what is significant knowledge and a valuable future, as developed in his social setting. (Mellin-Olsen, 1981, p. 357)

The S-rationale can manifest itself in various ways, since the significant knowledge motivated by the students’ social environment differs between gender, class, ethnicity and culture, and cannot be determined as a static set of claims. Different conceptions of what constitutes “good knowledge” may cause the student to have conflicting rationales for learning. While finding herself to be bored beyond belief by mathematics, she may very well be aware of the fact that mathematics is inevitable for moving on to the next level of the educational system. This reproduction of labour force, with mathematics as a gatekeeper, is represented by the I-rationale for learning. Mellin-Olsen explains the I-rationale for learning as follows:

It is the rationale, which is related to school’s influence on the future of the pupil, by the formal qualifications it can contribute. This role as an instrument for the pupil will provide the pupil with an instrumental rationale (I-rationale). In its purest form the I-rationale will tell the pupil that he has to learn, because it will pay out in terms of marks, exams, certificates and so forth. (Mellin-Olsen, 1987, p. 157)

The optimal situation for learning is that the S- and I-rationale coincide (Mellin-Olsen, 1981). This is the case when the teaching practice supplies the learner with a mathematical experience that fulfils the student’s desire to get good marks and provides relevant knowledge for her social environment. This situation will fluctuate due to mathematical topics and the teacher’s choice of teaching approaches. For example, adult students might find the calculation of interest rate highly applicable in their everyday life, while probability often appears less useful. Therefore, since educational programs typically deal with a variety of mathematical topics, a situation of constantly coinciding rationales is unlikely. Conversely, it is unlikely to have a situation where the S- and I-rationale are disjointed over time, since students’ will not find all mathematics taught to be out of their scope of social distribution. Mellin-Olsen claims that the major task of the teacher is to make the overlap of the S- and I-rationales as large as possible. This can be particularly complicated when a student is receiving conflicting messages from different parts of her social system, like parents, peers and teachers. If the student receives such conflicting messages without herself being aware, it can according to Mellin-Olsen (1981) lead to what Bateson (1973) calls a double bind. For example, a student can
expect to pass mathematics easily due to social class, well-educated parents and successful siblings. However, it turns out that she needs substantial support, which may appear unreasonable for the student. This can lead to conflicting rationales for learning.

A strong I-rationale together with a weak S-rationale is enough, but not ideal, for motivating the student to work with mathematics. However, if the I-rationale breaks down, the teacher needs to activate the S-rationale to evoke the student’s interest for mathematics as a subject. Through the S-rationale the teacher can build the student’s confidence as a capable mathematics learner, and make the I-rationale work again (Mellin-Olsen, 1987).

Methodology

The research reported here has been carried out by the two authors, where the first author act both as a researcher and the teacher for the student dealt with in the paper. The second author has been a visiting researcher and had no previous connection with the student or with the prison education system in general.

Educational Setting

The Swedish prison education program offers the option to study lower and/or upper secondary courses, while serving a prison sentence. Curricula are the same as in the adult education in regular schooling. These courses correspond either to some of the upper secondary mathematics courses or to the compulsory school mathematics in grades 1–9. The target group is adults without an upper secondary diploma, and of special focus are young adults who have difficulties in entering the job market. All studies are planned in consultation with a study- and careers advisor, whose profession is to guide students’ choices of educational paths towards their desired future occupation. The teaching is organized as individualized instruction, which means that students are enrolled in courses running continuously, without specific starting dates. The consequence is that almost all students either study different courses, or the same course but with different starting points. A great deal of the teaching is organized as distance education, where the teacher and student communicate through an intranet and via telephone. This organization may create a learning situation where students are denied opportunities for collaborative learning with peers. However, the teachers are free to organize their teaching with respect to the special conditions in their prison, and the same course can be carried out in very different ways. The one common guideline for all teachers is that the students’ needs and special conditions shall be the basis for the design of their courses.

For students with a locally stationed mathematics teacher, different students in the classroom are working with different curricula at the same time, as a result of different times of enrolment and the several courses running at once. The teacher (first author) of the student dealt with in this paper does not consider this to be a problem, since many major mathematical ideas and perspectives go across both compulsory school mathematics and the first courses in upper secondary school. Therefore, there are opportunities to let the students work together with the same mathematical themes, despite attending different courses. The aim of this teaching approach is to give the students opportunities to discuss mathematics and to learn from each other. The typical organization of the learning situations is that in the morning, the teacher poses a question verbally and in writing. In whole group discussion, the teacher seeks to reach a shared understanding of the problem, together with her students. After that, the teacher leaves the students to work with the problem individually. When each student has come to some answer, they turn to each other to explain their reasoning and argue for their solution. When all students have agreed upon a solution, they tell the teacher, who then chooses someone to come to the whiteboard to explain the solution and argue for its relevance. The other students support their peer when needed. If there are weaknesses in the students’ reasoning, the teacher questions those without revealing if the answer or procedures used are correct. The students are then left
to review and revise steps in the modelling-cycle, procedures used and arguments given in their solution to the problem, after which a further discussion about the solution is held. At the time we collected our data, the number of mathematics students varied from 3 to 5 in the study group, spread across three different courses. Besides the collaborative work, students are given individual hand-in assignments related to course-specific content that is not appropriate for the whole group. These assignments are not only chosen to match the course, but also to match the student’s interest and competence. In addition, students are also given other individualized assignments, not only mathematics tasks, but also texts or books about mathematics. This may include popular science books about mathematical matters, chosen to help the student gain interest in mathematics. Examples of such books include The Code Book and Fermat’s Last Theorem (Singh, 1998, 2000).

**Data Collection**

To investigate if one can use the S- and I-rationales to characterize students’ motivation for studying mathematics, we conducted and analysed semi-structured interviews with imprisoned adults, studying mathematics in the prison education program. Here we focus on the student Bill. Out of the students interviewed, Bill’s story seemed rich enough and of enough complexity to offer an interesting methodological challenge. The sample is therefore purposeful (Coyne, 1997) in relation to our aim of investigating the applicability of the S- and I-rationales. Bill was interviewed on three occasions. The first interview lasted 39 min and took place on 3rd October. The interview was thematically structured around five themes: what he was currently working within the mathematics course; how he perceived his progress; if he had used mathematics in his working life; why he was studying mathematics; and a comparison between the school context today in relation to earlier school experiences. The second author of this paper conducted the first interview. He had not had contact with the student prior to the interview. We considered that there might be a risk of bias in the answers if his teacher (the first author) had been conducting the interview, since it is likely that the student would feel a sense of loyalty to his teacher and therefore may be less critical in his answers. Bill was asked if he would participate voluntarily, which he agreed to do. Because he was a student of the first author, the interview data could be understood in relation to Bill’s individual course design. The second interview was conducted on 2nd December. This interview was initiated by Bill and carried out by the first author (the teacher). The interview lasted for 21 min and was driven by Bill’s wish to share his own new thoughts about mathematics with his teacher. The third interview took place on the 30th of June and it lasted for 12 min. At that stage, Bill had completed his mathematics course four months earlier. The interview was initiated by the first author, his teacher, and the theme for that interview was Bill’s retrospective reflections on his mathematics studies in prison and his rationales for future studies outside of prison. Since the course was already completed and graded, we considered the distribution of power between teacher and student to no longer pose a problem for the honesty of the interaction.

Drawing on Powell et al.’s (2003) principles for analysing video data, the interviews were audio recorded and all parts concerning Bill’s relation to mathematics were transcribed. The transcripts were analysed by the authors together. We coded all critical events referring to Bill’s rationales for studying mathematics and categorized them as belonging to the S-rationale or the I-rationale for learning, in line with the operationalization described below. Thereafter we constructed a storyline, which formed the basis for a chronological narrative of Bill’s history of rationales for studying mathematics. While the timeline was constructed in relation to Bill’s chronological experiences from schooling, critical events relating to one time segment in Bill’s life came from different time points in the interviews.

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3The study was carried out in sometime between 2014 and 2018. To respect the student’s anonymity, we have chosen not to specify what year the study was conducted.
Method of Analysis

The rationales were operationalized as follows, using a priori understandings of the I- and S-rationales from Mellin-Olsen’s (1981, 1987) descriptions, statements concerning explicit or implicit ideas about passing a course, getting a grade or using a formal qualification for admittance in higher education or for job seeking purposes were classified as I-rationales. Statements such as: “I just want to pass the course and get a grade.”; “I am not interested in learning something unnecessary, that does not belong to the course.”; “I must take this course to be able to apply for …” all express an I-rationale for learning. Statements concerning motivation grounded in either joy of doing mathematics, a wish for the positive experience of being a knower of mathematics, or a wish to obtain mathematical knowledge that is useful now or in the future were coded as S-rationales. Statements such as: “This is fun.”; “I can understand that you can have good help in life from knowing this.” “I would be cool to understand mathematics.” all express S-rationales.

The displayed excerpts are translated by the authors. We acknowledge the difficulties in capturing the meta-functions of the text (Halliday, 1973), and how they can be lost in translation. To the best of our ability, we translated the text to mirror both the ideational function and textual function in the interviews. Before presenting the results, we will give a brief description of the educational setting of Bill’s mathematics prison education.

Results

When the first interview was conducted, it has been 15 years since Bill studied mathematics in upper secondary school where he barely managed to get the lowest grade in the first course. During the second course, he gave up, with a feeling that mathematics was not for him. He terminated his upper secondary program after two years out of three without a grade in the mathematics course B4 and he is now studying course 2 which is the corresponding course in the current system.

Bill: I will tell you an anecdote … I was rather tired of school, and particularly so of mathematics course B, quadratic equations or some kind of equations anyhow, but I recall they were quadratic. I tore my hair and said to myself, because I had that feeling that now … I will manage this […] and at last I solved it. And I got that feeling that now, now I grasp this.

Bill: The next day I entered the classroom with feathery steps and kind of sat down and realized that I had forgotten everything … then I made it my truth … that mathematics is not for me. I’m kind of afraid that it will happen again.

Bill: I have a saying, for myself; that mathematics feels like trying to look left and right at the same time (interview 1).

We interpret this as a breakdown of the I-rationale for learning. Bill no longer believed that he was able to get a grade, so he gave up. When Bill returns to mathematics 15 years later he still has a crystal clear memory of the event that lead him to lose faith in his ability to master mathematics.

Bill: I have a, kind of, personal trauma with studies … My family is all overachievers and now I am in my thirties … in upper secondary school … they said you are clever, actually. [referring to teachers and parents commenting on his weak school results]. But it was hard for me … already in lower secondary school (interview 1).

Here we identify a conflict in the S-rationale, a double bind, between Bill’s self-concept as coming from a family of overachievers and his experience of struggling for results in school. His social distribution makes Bill, as well as his parents and teachers, expect him to not only pass grades, but also be the kind of student that is a successful learner in the school context. Since this primarily concerns the acquiring of mathematical knowledge, not grades, we interpret this as related to the S-rationale.

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4Mathematics B was the second course in upper secondary school in the former Swedish national curriculum, that was replaced in a reform 2011. The present upper secondary course system consists of course 1 in variants a, b and c, course 2 in variants a, b and c, course 3 in variants b and c, and course 4 and 5.
Our interpretation is that Bill’s failure to fulfil the social expectations that come with the class led to a weak S-rationale. Yet, the fact that he returns to mathematics when given the chance during his prison sentence, is an indication of a re-established I-rationale:

Ola: Why have you chosen to study mathematics? After all it is voluntarily.
Bill: It is something I need … it is in my plan for my studies (interview 1).

Bill has a study plan made by a study and careers counsellor. His goal is to get formal qualification for tertiary school. Despite his earlier experiences he decided to give mathematics another try, based on an I-rationale for learning. But after studying mathematics for two months, Bill’s S-rationale has changed:

Ola: Can you tell me what you are working with right now?
Bill: It is a lot about proportions [laughing] … and how to relate. And for the first time I find it thrilling.
Bill: This is something I think is fun … I don’t know if it will last. I took off from an intention to just do it. I didn’t care a f*** if I only managed to barely reach the lowest grade. Like, this will not be fun, I just have to cope. But now, I’m starting to feel […] it would be fun to understand (interview 1).

Bill shows a growing interest for mathematics as a subject. The S-rationale is evoked and Bill expresses his experience of mathematics as “thrilling” and “fun” although he is unsure if this state of mind will last over time. Bill declares that in the beginning of the course he just wanted to pass and get a grade, an indication of a strong I-rationale. Now he is saying that it would be fun to understand mathematics. This is something else than to just reach a grade. It is an expression of wanting to know mathematics, and it invokes the S-rationale. At this point, Bill expresses that the I- and S-rationale coincide, which in Mellin-Olsen’s theory is the optimal results of a teaching practice that both gives the learner a mathematical experience that fulfils the student’s desire to pass the examinations and at the same time provides relevant knowledge for his social environment.

Two months after the first interview, Bill’s rationales for learning mathematics have undergone further changes. He declares that he has been thinking about himself, in relation to mathematics, and he wants to share his new insights with his teacher.

Linda: Tell me what you are thinking about?
Bill: Something fascinates me, something very attractive … a kind of skill and passion for a topic, and mathematics is that kind of topic. I did not grasp it before, that it is the kind of topic where you can be very … that makes you feel strongly, somehow.
Bill: How I want to relate to mathematics? Just seeing it as useful is all gone for me. I see no relevance for employment, no relevance for further studies. Maybe I need mathematics for getting the formal qualification for further studies, but then only the lowest grade, but besides that I want learn because it is cool (interview 2).

Bill’s rationales for learning have changed. Doing mathematics connects to his feelings. It is not the usefulness that triggers him. Bill wants to learn because he now finds himself fascinated by mathematics as a “cool” subject. We interpret this as a growth of the S-rationale, which now overrides the I-rationale that is much weaker than in the beginning of the course. The I-rationale is still there, since he might need the qualification. In this case the S-rationale is not connected to the usefulness of mathematics, but to the attraction to the subject as it is now portrayed.

Time goes by and Bill completes his course. He has now developed all but one of the competencies necessary for the highest grade (A), the exception being his low confidence in the choice of methods, which landed him on a B-grade. The teacher’s interpretation is that Bill doubts his capacity, despite his new-born interest in mathematics as a subject and all his successful engagement in doing mathematical activities. When the course is completed and it is time for Bill to leave the prison and go on parole, the teacher asks Bill for a talk to retrospectively analyse how his studies had changed his relation to mathematics.

Linda: You said before when we talked that mathematics is not for you.
Bill: Hhum
Linda: What’s your view on that now?
Bill: Oh, what a frigging question. […] (Talks about himself and prison in general). I don’t know if mathematics is for me. It is hard to say. I thought that it was great fun to read these books. They kind of triggered my imagination. Moments of fantasy, then it is fun. That is how my brain works. But when, when it feels unimaginative, then it becomes, then it becomes much more boring.

Linda: Remind me. Which one did you read? Hardy’s apology (Hardy, 1967), and Singh’s Fermat’s last theorem (Singh, 1998)?
Linda: But if you would continue to study mathematics now, how do you think you should cope?
Bill: I do not know. I have been thinking about that too … Ehh … Something has stuck quite clearly, and it is possible that it would go quite well but … it feels like it has kind of been very fun to do it here, because it has been a commitment around it, and it has sort of been fun, and has become an intellectual game in a way. But if I should jump in to Komvux [referring to adult education in society outside prison, our remark] to do mathematics B or 2 [referring to the following course, our remark] in five weeks I am not sure that I could keep up … Because I might lose the feel of joy getting these things.

Linda: You think more of the context than the mathematics, but if you consider the mathematics. What if you sat at home with someone to discuss with?
Bill: No, that could be the case. I think my thoughts are stuck in the typical Swedish schooling model for mathematics. You sit with a book with long sequences of symbols … ehh … it is very solution oriented or answer oriented and it is so square. And that does not suit me that I can say (interview 3).

Even though Bill’s S-rationale has grown strong during the course, he doubts that he can fulfil a mathematics course outside the prison context. The joy Bill feels about mathematics as a subject is precious to him and he does not trust his new-born fascination for mathematics to survive in a different school setting. Bill seems to think that the mathematics teaching in prison is different for him compared to the teaching in the regular Swedish school context. Hence, the S-rationale appears to be dependent on the school milieu, not only a relation between the student and the mathematics.

Linda: Say that we had mathematics as a hobby, to solve a problem every week and then discuss it. Do you think you would you have a problem with that?
Bill: No
Linda: No? So you think you could engage in mathematics as a science?
Bill: Yes, I do believe that. I actually believe that. […] that’s the thing, you get the feeling that when you did this … the application of mathematics, how you approach mathematics is infinite, the possibilities, sort of. You could start from a musical perspective. You could come from any angle and really tailor the application of mathematics … and it’s a real pity that you don’t. So yes, absolutely. But if you ask me how I think it would go if someone just handed me the books for course 2 and said, here you have five weeks to pass, then I don’t know (interview 3).

When Linda focuses Bill’s attention away from a possible future school context and onto the actual mathematics Bill expresses faith in his ability and positive feelings regarding mathematics. This reinforces the interpretation that the S-rationale is strongly dependent on the context in which mathematics is studied, not only when thinking retrospectively about one’s mathematical experience, but also when thinking about future mathematical experiences.

**Discussion**

We have described how you can characterize students’ motivations for studying mathematics in relation to their social context, by means of Mellin-Olsen’s concepts S-rationale and I-rationale (1981, 1987). Our question is theory driven, with the primary purpose being to examine the methodological feasibility of such an operationalization by analysing three interviews from three different time points with a student. Hence the results are empirical, providing an image of how the rationales of the student, Bill, can be characterized and how they change over time. We will discuss these results in terms of the applicability of the concepts of I- and S-rationales, as well as in relation to other research on motivation.
From our analysis, we conclude that Bill’s I-rationale broke down when studying mathematics in upper secondary school, due to a failure to sustain a feeling of coping with the challenges. Fifteen years later when Bill is serving a prison sentence, he takes the opportunity to study mathematics in the prison education program. Bill’s I-rationale is working again. The first interview reveals that Bill’s S-rationale was initially weak. During his studies, the S-rationale strengthens, driven by a growing desire to master mathematics. In the second interview, the S-rationale even overrides the I-rationale. The third interview confirms a sustained S-rationale for mathematics as a subject, even after the course is completed.

For Bill, the S-rationale grew stronger while the I-rationale weakened. This is not necessarily always the case. It is easy to imagine that when the S-rationale grows, the I-rationale grows too. However, rationales change over time. It may be a delicate mission for the teacher to organize teaching that maintains the S-rationale. A fall-back strategy might then be to try to evoke the student’s S-rationale and at the same time avoid a breakdown of the I-rationale, caused by the student losing faith in ever understanding mathematics and reaching a grade. When teachers challenge a student with a weak I-rationale, they need to be attentive and prepared to guide the student in his struggle with the instructional activities. Leaving students without support may result in broken I-rationales, as we could see was the case for Bill in upper secondary school. Since the I-rationale is triggered by the expected value of school mathematical achievement but limited by the experienced likelihood of not achieving, teachers attending to the I-rationale can learn from self-efficacy theory (Bandura, 1977, 1997) and expectancy-value theory (Wigfield & Eccles, 2000). Both these theories in different ways describe relations between a person’s beliefs about succeeding with a task and the value the person places in succeeding. For example, expectancy value theory account for a person’s previous achievement experiences and how they relate to a subjective task value. This explains why teachers of students with previous experiences of failure need to be very careful when challenging the students with new tasks.

The S-rationale however, is harder to understand in terms of motivation constructs. It is worth noting, that the general instructional context described in the methods section includes the type of factors described by research as important drivers of intrinsic or integrated extrinsic motivation: competence, autonomy and relatedness (Ryan & Deci, 2000). However, in the story of Bill and his growing S-rationale, it is not the general instructional context he refers to, but the changing view of mathematics as a subject. The part of the teaching that made it possible for Bill to discover the side of mathematics that intrigued him was not the general teaching but the choices the teacher made for Bill, in particular based on his non-mathematical interests in life. We call to attention the case of Bryan described by Williams and Ivey (2001). “However, we argue both empirically and theoretically that none [of the most popular theories of motivation] serve to characterize what we feel is the core of Bryan’s decision about engagement: his affective assessment of mathematics” (p. 75). Williams and Ivey note that what the practice of mathematics actually entails influences Bryan, something that is at the core of the S-rationale. Mellin-Olsen discusses students’ metaknowledge of mathematics by which he means their views on what the subject is for: “there exist two extreme forms of metaknowledge: mathematics as something which is experienced as a set of tools for Activities (S-rationale), excluding School as a possible Activity, and mathematics as something which belongs to the context of school and only that (I-rationale)” (Mellin-Olsen, 1987, p. 179). When Bill develops his S-rationale it is however not this utilitarian perspective that dominates. He explicitly states “seeing it as useful is all gone for me”. Bill’s S-rationale is instead connected to the practice of doing mathematics in a particular way. Or more precisely put: when mathematics is considered as an amalgam of content and practice, the mathematics Bill now enjoys it is another mathematics than he experienced before. It is experiencing a creative and challenging mathematics that invokes his S-rationale. We therefore suggest that when thinking about students’ S-rationales, it is important to acknowledge that it is not only the mathematical concepts, methods and tools that need to be in tune with the student to form strong rationales. The teachers’ organization of the mathematical practice is just as important.
In Bill’s case the S-rationale was catered for by using his appreciation for words and his interest for history. He was very fond of literature and he liked to discuss and analyse social and political phenomena. This interest was put to play in Bill’s mathematics studies by including popular science novels as a part of his course design. He read the books *Fermat’s göta* [Fermat’s last theorem], *Kodboken* [The cracking code book] and *Räkna med Simpsons* [The Simpsons and their mathematical secrets], by Simon Singh (1998, 2000, 2014) and Hardy’s *A mathematician’s apology* (1967). This provided an entry into number theory, proofs and discussions about pure and applied mathematics as well as specific mathematical applications like coding and public-key cryptography, like RSA. The case of Bill is an example of the fact that it is possible to evoke an S-rationale by addressing mathematics connected to a student’s interest.

A final remark concerns the connection between students’ rationales and the teaching context. Despite the apparent strength of the S-rationale, Bill himself expresses doubt that he would be able to uphold it in a regular school context. This may seem contradictory since Bill clearly expresses his new positive feelings about mathematics to be about the subject itself and not the teaching of it. But in fact, this connection between the S-rationale and the context is explainable by recalling that mathematics is not only content but also a practice. How mathematics is practiced always depends on the mathematical context and culture. In our interviews with Bill, he starts out by saying that mathematics is not for him, depicting this to be a relationship between him and the subject. But as his prison education goes along, he not only regains his S-rationale, he also comes to understand that his feelings about mathematics refer not to the subject itself, but to how it is practiced in different contexts. Bill himself also describes the teaching situation in prison as clearly different from what he experienced before and from what he expects to meet again if he were to re-enter regular mathematics education outside prison. It is known from previous research that students can adapt quickly to the norms of a new type of teaching while simultaneously seeing the new teaching as “not normal” in contrast to the institutional norms of the regular schooling experienced before (Liu & Liljedahl, 2012). This illustrates that no teacher can expect students to come pre-loaded with rationales, regardless of previous mathematical experiences. In the end, it will be the mathematical culture in the current context that prevails.

To summarize, the main claim of this study is that we have shown the possibility of describing a student’s mathematical life in terms of S- and I-rationales and that the development of the rationales can retrospectively be associated to different teaching and learning situations that the student was subjected to. Moreover, when relating Bill’s description of his prison education experience to our analysis of his growing S-rationale, we believe that the individualized instruction he got, was an instrumental part of his changing rationales.

A main aim of this study has been to operationalize Mellin-Olsens constructs. We have done that by applying the theory on the analysis of a student that is currently taught by the first author. We tried to minimize the risk of this relationship influencing the results by letting the second author conduct the first interview. Later however, the student himself initiates a second interview, which is conducted by the first author (the teacher). Obviously, the student-teacher relationship might influence what the student chooses to say, but our main aim has not been to extract an objective image of Bill, but to show that it is possible to use the I- and S-rationales for analytical purposes. Therefore, we don’t see the possible teacher/researcher conflict as particularly problematic in this case. A bigger problem is that the paper includes information about the teaching of the student provided by the teacher (first author). However, we have systematically used such information as contextual background in the methods section or as additional background information in the discussion. This means that the contextual information is not instrumental for the analysis, only for putting the results in context. For this purpose, as pointed out by Lampert (2000), the perspective of the first person (teacher) is an advantage.

This study has been carried out in the rather special context of individualised instruction in prison education. The prison context constitutes a setting that from a sociopolitical point of view in itself deserves research interest. However, conventional teaching rarely has possibilities for individual
instruction, so the generalizability of the results outside prison education can be questioned. But when Mellin-Olsen in 1981 discussed rationales for learning as an applicable lens for framing information about the nature of students’ reasons for studying mathematics, the aim was to inform the teacher so that the teaching could be adjusted to the students’ needs. The key point is: shall the teaching adapt to the students or shall the students adapt to the teaching. Mellin-Olsen had his position clear: “If the pupil stops learning because both the I- and the S-rationale have ceased to function, a remedial education has to build on a revitalization of the S-rationale” (Mellin-Olsen, 1987, p. 159). In all levels of the educational system we have students that cannot cope with the given instruction. They are in need of remedial education and special instructional attention of other kinds. Mellin-Olsen claimed that a strategy of instruction with more of the same type of instruction that the learner did not cope with initially may aggravate the learning problems. Thus, another organization of instruction is necessary. If you believe this to be true, the feasible path to successful remedial instruction is by adapting the instruction to the student instead of encouraging the student to change his attitudes towards the instruction that initially led to the breakdown of the student’s rationales. In this line of thought, a practical contribution from our study is that the S- and I-rationale constructs can be an applicable cognitive tool which can assist teachers when collecting and analysing crucial information about their students’ social distribution.

Disclosure Statement

No potential conflict of interest was reported by the author(s).

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