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When researcher and teacher talk past each other: an IR analysis

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This paper discusses influential factors in an implementation of a longitudinal innovation based on results from research on beliefs, especially reflection, in mathematics education. As part of this innovation, the researcher constantly found herself to be “talking past” the involved expert teacher, who was responsible for implementing the innovation in the classroom. In particular, three influential factors appeared to play a central role in the case presented in the paper: characteristics of the particular end-user; attributes of the innovation; and not least implementation support strategies.

Keywords: Implementation research; influential factors; reflection; beliefs; probability.

Introduction

In a longitudinal study aiming to develop middle school students’ beliefs about mathematics, the first author experienced that despite good intentions, long preparations, careful planning, and coaching of the involved teacher, the “reality” of what was implemented in class was far from the agreed-upon initially designed activities. We hypothesize that constructs from IR may shed light on this. Hence, our research question may be phrased as: Can theoretical constructs from IR provide explanations as to why the researcher and teacher of our longitudinal study managed to talk past each other for a period of two years on the topic of ‘reflections’? And if so, then in which respects, and to what extent?

With our answer, we hope to provide some illustration that IR may have something to offer the explanation of phenomena present in qualitative studies in mathematics education research. This paper thus addresses influential factors in relation to the implementation of designed teaching units to foster reflections with students concerning the nature of mathematics as a discipline.

IR theoretical constructs

When attempting, as in our longitudinal study, to change educational practices, the complexity of the setting fosters a variety of factors influencing the process, depending on both the characteristics of the innovation and the level of change (e.g. individual or organizational level). On an individual level—as in the case in this paper—a change in practice, e.g. for a teacher, can be both challenging and psychologically threatening, as well as cause doubts and uncertainties (Century & Cassata, 2016), even when the intended change might not seem difficult to its promoter. Other influential aspects might be the character of the innovation, environmental factors, support strategies, or time. Century and Cassata (2016) present a list of factors that might influence the implementation of an innovation. Here, we address and connect three of these in the analysis of the implementation in our selected case: characteristics of end-users; attributes of innovation; and implementation of support strategies.

The characteristics of individual end-users of an innovation (who in this case are the teachers, as we investigate the process of implementation of teaching principles) can potentially play a crucial role in an implementation process, not least in innovations that give room for the users’ interpretations and adaptations. Prior knowledge, individual competency, professional identity, and feeling of agency are all examples of factors that might influence the implementation. In this regard, Rogers
(2003) mentions different types of knowledge connected to the implementation process, e.g. *how-to knowledge*, (practical knowledge about how to apply the innovation) and *principles-knowledge* (understanding the thoughts behind the innovation). Century and Cassata divide the characteristics of the end-users in two: (a) those related to the innovation, “e.g. level of understanding, expertise, prior experience, beliefs, values, attitudes, motivation, or self-efficacy” (p. 185); and (b) those existing independently of the innovation, “e.g. willingness to try new things, organizational skills, classroom management style, or views about teaching and learning in general” (p. 185).

*Attributes of the innovation* include both objective characteristics of the innovation (e.g. number of components or design features) and subjective user perceptions (e.g. relevance or ease of use). Some innovations are rather explicit, specifying the innovation in detail, which does not leave room for the users’ adaptations. Others are more ambiguous and thereby more dependent on the interpretation and realization of the users.

*Support strategies* can be essential in an implementation process, and should according to Century and Cassata (2016) ideally be included in an innovation, based on underlying theories. Support to the users in their process of change can appear in various formats, e.g. professional development, strategic planning, or evaluative processes.

**Setting the scene—the overall project and the central element of ‘reflection’**

Our two-year longitudinal study began in 2019 in two Danish 6th grade classes. The study used a Design-Based Research approach, involving two mathematics teachers in designing certain teaching principles, as well as in the implementation, evaluation, and adjustment of these principles in iterative cycles. The hypothesis behind the study was that a longitudinal change of focus in the teaching of mathematics can contribute to a change in the students’ beliefs about mathematics—specifically that an increased focus on (1) the application of mathematics; (2) the historical development of mathematics; and (3) the nature of mathematics as a subject (Niss & Højgaard, 2019), can influence their beliefs about mathematics as a discipline. Hence, the main focus of the overall study is the development of students’ beliefs, and not as such the teachers’ professional development. However, as the present study addresses issues related to the implementation process within the overall study, the teachers thus become the focus here.

Philipp (2007) defines beliefs as “lenses through which one looks when interpreting the world” (p. 258). Because of the stability and psychological importance of beliefs, changing students’ beliefs can be both difficult and time-consuming (Green, 1971). A central element in this process is *reflection*. Beliefs that are developed based on experiences or reason can be said to be *evidentially held*. In contrast, *non-evidentially* held beliefs are either transferred from others (e.g. teachers, parents, stereotypes, etc.) or derived from already existing beliefs, and these tend to be more difficult to change with reason. Non-evidentially held beliefs can often be illustrated as convictions of the sort that are impossible to argue against. Hence, when educating students, attention must be paid to providing examples and opportunities for experiences on which they can base and develop their beliefs to ensure that these are evidentially held. However, if such beliefs are to last, the provided evidence must necessarily be followed by reflection. Relations between beliefs are established when reflections are considered and assessed (Green, 1971), and these relations are what include and maintain beliefs in a cluster, hence making them more stable. “Reflection” thus played a central part in the study.
Even though the designed teaching principles were adjusted along the way, four main principles were consistent during the two years of intervention. That is, all teaching modules included: (1) concrete examples of the application and/or the historical development of mathematics; (2) mathematical problems and methods; (3) dialogue about the application, the development, and/or the nature of mathematics; and (4) individual and/or shared reflection. As Gregersen et al. (2019) point out, teachers’ principles-knowledge can increase their experience of an innovation’s relevance. The participating teachers were thus introduced to the importance of reflection in the initial phase of the study. The connection between changing beliefs and students’ reflection was communicated in two ways: First, in a document stating the purpose of the intervention and the role of reflection when aiming to change or develop students’ beliefs. The word “reflection” was highlighted and mentioned five times in the document to illustrate its centrality. Second, the document was discussed in a subsequent meeting between teachers and researcher, where the importance of reflection was further emphasized. In the following, we present an illustrative case of how one teacher attempts to realize the intended teaching principles, with a special focus on reflection. The case revolves around a lesson concerning probability that was planned in collaboration between researcher and teacher. We investigate three phases of the implementation process: planning, implementation, and evaluation. Thereby, we are able to compare the intention, the realization, and the teacher’s considerations behind any deviations from the intention. The data include sound recordings of planning and debriefing sessions, as well as video recordings and field notes from the lesson. Furthermore, we include excerpts from a meeting six months prior to the lesson to illustrate the teacher’s general considerations about students’ reflections. In our analysis of the data, we apply the above-mentioned theoretical constructs from IR, thus seeking an explanation to the apparent miscommunication between researcher and teacher regarding the concept of reflection within the overall study.

**An illustrative case of one teacher**

Six months into the intervention, the teacher in our case explained how the teaching principle related to reflection had caused her to be “more systematic about individual and shared reflection, and what it can be used for”. Although she had 20 years of teaching experience and was the school’s mathematics counselor, she still felt that the principles, in general, made her more aware of her teaching choices. When the other participating teacher described her difficulties with implementing reflection, the teacher of this case even argued why reflection is important, and how she motivated her students to reflect:

> I have spent time in the class talking about short-term memory and remembering to bring it [the learned content] back to the working memory—you need to think about it and bring it back. And if you don’t do that several times, the brain will toss it. (…) So there is a reason that we do it [reflect].

Hence, the teacher appeared to be conscious of the importance of reflection and its role in the project. However, she also gave a small hint of doubt, expressing that she was not sure that she was always able to transfer her intentions “all the way into the classroom”. The following case, which confirms this doubt, took place six months later (a year into the intervention).

**Planning**: To ensure that the purpose of the intervention was met, the researcher participated in the planning of at least one lesson within every teaching sequence. In a sequence about probability, the topic of a 90-minute lesson was chosen to be the historical development of the field, exemplified in
Pascal and Fermat’s approaches to solving the question of distributing stakes in an unfinished game of chance, as presented in a simplified version by Berlinghoff and Gouvea (2004). The problem concerns a game of flipping a coin for two players. Each player stakes €10 and tosses the coin in turn. If heads, the player tossing the coin gets a point; if tails, the other player receives a point. The winner is the first to reach three points. However, the game is interrupted, when the score is 2-1 in favor of the player about to toss the coin, and the distribution of the €20 stakes is to be decided. The planning of the lesson was based on Chapter 21 of Berlinghoff and Gouvea (2004, p. 207-214): “What’s in a Game? The Start of Probability Theory”. This chapter describes the story and the mathematical theory behind the problem as well as the methods used for solving it. Since both teachers had expressed some doubts about how they could implement the teaching principle concerning reflection, it was agreed that the students’ considerations, suggestions, reflections, and discussions should be the focus of the lesson. Space for reflection would be given in the students’ discussions of each other’s solutions, and the relation to the solutions of Pascal and Fermat. Our teacher expressed her intention to “let the students consider a solution themselves”, with the purpose of allowing them to “experience frustration and give their contributions”. She also suggested that part of the students’ reflections could regard the validity of the methods presented by Pascal and Fermat. She wanted to engage the students in the role of experts to act as mathematicians by showing them that some of their considerations and conjunctions could be compared to those of Pascal and Fermat. After an exchange of ideas, the lesson was planned to include five activities, which are listed below. Each of these activities was thoroughly discussed, both in regards to the content and the purpose in relation to the goals of the lesson. Several activities relied on the mentioned book chapter, and thus the teachers should make themselves familiar with its main points, especially regarding the mathematical methods involved.

**Implementation:** Below, the five activities of the 90-minute lesson are described in terms of the content of each activity, the intention decided by the teachers and the researcher in the planning process (purpose), and the actual realized implementation (reality).

**Activity 1:** Presentation of game, the distribution problem, and Pascal and Fermat. Told as a story.  
**Purpose:** Engaging the students by telling a story, and inviting them to “play along”. Introducing the historical persons involved, and inviting the students to consider a distribution of the stakes.  
**Reality:** The teacher told a story about a rich, French, 17th-century nobleman, who liked to gamble. Concept of ‘stakes’ and rules of the game was explained. Pascal and Fermat were never mentioned.

**Activity 2:** In pairs, the students play the game and consider the distribution of stakes. Coins are available. The pairs present their suggestions. Subsequently, pairs with deviating solutions are put together in groups of four, who discuss their suggestions and try to agree on a shared solution.  
**Purpose:** Becoming familiar with the game and the problem. Expressing immediate suggestions for a solution, which might involve discussion and argumentation. Considering possible scenarios of the outcome of the game, leading to mathematical considerations. Making the students reason and argue by pairing groups with different solutions.  
**Reality:** Handed a wooden coin and eight pieces of paper (money bills working as stakes) on which they could write the number 10, the nine pairs of students played the game four times. After a while, the teacher stopped the games and asked the class if they believed this game to be fair. Several students complained that their coin always landed on the same side. However, the teacher neither engaged in a dialogue about the concept of fairness, nor what such a bias would mean in regards to
the game. Instead, the students were asked to play again and stop when one player had 2 points and the other 1—and then discuss how the stakes should be distributed if the game could not be completed. The students did, and the teacher circled between them asking guiding questions: “How is your distribution fair?”; “Would you both be satisfied with that solution?”. She noticed that most pairs either assigned all the stakes to the player with 2 points, or shared the stakes evenly, and she stopped the students. When asking each pair for their solution, this tendency was affirmed. Even though the teacher asked questions that might make the students reflect on probability (e.g. “Who has the largest chance of winning?”), they never engaged in any mathematical consideration. The teacher asked them to play again, this time stopping when the points were even. Expectedly, they found the distribution easier now that the probability of winning was equal for both players, which was pointed out by the teacher. She now encouraged the students to have a “serious discussion” about the distribution in the case of 2 points versus 1, making them aware of the possibility to exchange the €10 bills. The pairs were sent on a 2-minute “walk-and-talk”, which should result in an agreed solution to put on the whiteboard. Thereby, the original intention of putting pairs together with different solutions was never realized. Neither was the intention of having the students prepare a mathematical argument for their solution.

Activity 3: Presentation of solutions, the arguments behind them, and the strategies to reach them.

*Purpose:* Having the students explain their suggestion for a certain solution, and the method for reaching it. Comparing different solutions and different methods and arguments. Including arguments and strategies behind the solutions to emphasize that reasoning and methods are important aspects of mathematics, which are needed to make well-informed and accurate decisions.

*Reality:* The students put their solutions on the whiteboard. Out of nine pairs, four suggested that the €20 were distributed evenly, four suggested a 15-5 distribution, and one suggested that \( \frac{2}{3} \) of the money would go to the player with 2 points. The teacher merged the last suggestion with the 15-5 solution and asked the class to explain why this solution was fair. One student answered: “Because the player with the most points should have the most money.” The teacher asked for an argument behind the 10-10 solution, and another student answered: “Because they have equal chances of winning”. The teacher questioned this by drawing the students’ attention to the minimum number of tosses needed for each player to win. Another student exclaimed: “The chances are not equal, because one player has a 75% chance of winning, and the other has 25%”. Unfortunately, the teacher did not elaborate on this rather clever observation, although it appeared an excellent opportunity to engage in mathematical considerations. Neither the mathematical argumentation nor the strategies to reach a solution were discussed.

Activity 4: Shared classroom reflection: can we all agree on a solution? Which methods did we use? Were some solutions, methods, or arguments better than others? Which methods did Pascal and Fermat use? Did they resemble our methods?

*Purpose:* Comparing and discussing the solutions and arguments from the presentation. Offering the students an opportunity to reflect on their process and the mathematical ideas behind the different solutions as well as the validity of a mathematical argument. Placing the problem and their ideas in both a historical and a mathematical perspective by comparing the methods used by Pascal and Fermat. Illustrating the character of mathematical methods, and that the students too can engage in problems that mathematicians struggled with.
Reality: This activity was not realized in any way.

**Activity 5: Follow-up on the historical development of probability theory.**

**Purpose:** The work of Pascal and Fermat is considered one of the initiators of probability theory, soon followed by theories about e.g. the Law of Large Numbers, expected outcome, and analytical theory of probabilities. All of which are now applied in many fields such as medicine, insurance, business, law, etc. Making the students aware of this development and the importance of the field that sprung from the problem that they had just worked on, inserts mathematics in a context that exceeds school and illustrates its role in the world.

**Reality:** The teacher returned to the story of the French nobleman, who actually met this exact problem and asked “some mathematicians”. Pascal and Fermat were still not mentioned by name. Their methods and solutions were only mentioned as follows:

> What they came up with was actually some of what you suggested. Their solution is 15-5. Because there is a difference in the players’ chances of winning. They reached their solutions in a slightly different way as you reached yours differently. And they were great mathematicians (...). And you were also able to do this. And this was the beginning of the kind of mathematics that deals with probability.

Hence, the intentions of comparing the solutions and methods of both each other and of Pascal and Fermat were never realized, despite being the main goal of the lesson. The mathematical content was neither presented nor discussed, and the historical significance was only mentioned in bypassing. Most unfortunate was that the students were not offered the intended opportunities for reflection.

**Evaluation:** After the lesson, the teacher expressed that the class was not used to working in such an “unstructured manner”, and neither was she (not specified any further, though). She also admitted that she did not thoroughly read the chapter on probability. This may be the reason for the lack of mathematical content in the lesson. However, after a suggestion from the researcher, the teacher presented a mathematical argument for the 15-5 solution in a lesson four days later, by studying the possible scenarios if the game had been continued. In the subsequent debriefing, the teacher described her criteria for success in the lesson: “that the students are able to say ‘we have conducted an investigation, and it seems that…’”. Even though all the pairs did reach a conclusion during the lesson, the teacher appeared somewhat unsatisfied. She appreciated having a story to start from but felt that it was difficult to get the students to use mathematical argumentation. Furthermore, she regretted not making the students aware of the possibility of exchanging the bills earlier: “It was not until I told them that the bills could be exchanged that they started thinking about it. If they had received ten €1 coins instead, I wonder what might have happened.” She never addressed the skipped activities of reflection, nor the lack of the historical dimension. Her considerations—and the researcher’s observations—formed the basis for a discussion on how the students could be supported in their argumentation so that it could be more mathematically founded.

**Analysis and discussion of case in terms of IR**

**Characteristics of end-user:** There appeared to be a discrepancy between the teacher’s characteristics in relation to the innovation and those existing independently of the innovation. The teacher was an expert teacher, with a strong professional identity. She often advised her colleagues on mathematics teaching and learning. Concerning the innovation, she was highly motivated and perceived the
innovation as relevant, both for her teaching and in her professional development. Her statements in 
the planning phase indicated that she was very aware of the innovation’s intention and that she had a 
clear idea of how this intention was to be implemented. Our case, however, reveals that even though 
she possessed this principles-knowledge of the innovation, she might not have had adequate prior 
experience with the intended teaching approach, and thus her how-to knowledge was insufficient. 
Furthermore, her comments during the evaluation phase may be a sign that her identity as an expert 
teacher was threatened by the uncertainties and doubts that she experienced during the lesson. The 
fact that she did not mention the skipped activities of the lesson plan, which primarily involved 
reflection, seemed to indicate that she was not as aware of this purpose, contrary to what she expressed 
during the planning. Yet, it could also be a sign of denial of a feeling of failure or inadequacy.

Attributes of the innovation: As the innovation was based on a small number of somewhat general 
principles (cf. above), the level of explicitness was quite low. Hence, the implementation of the 
principles was highly dependent on the interpretation and realization of the teacher, requiring a high 
level of how-to knowledge. This meant that the final and determining decisions in the classroom were 
in the hands of the teacher, and thus became the realized innovation. Despite the shared planning of 
the presented lesson (supporting the teacher’s how-to knowledge), and the regular discussions 
regarding the centrality of reflection for the development of beliefs (principles-knowledge), the 
teacher still decided to leave out the activities offering possibilities for the students to actually reflect. 
Furthermore, to promote the teacher’s feeling of agency in the innovation, the allocation of 
contributions was that the researcher would primarily function as a theoretical expert and the teacher 
as an expert on practice. Consequently, the teacher was responsible for the detailed planning and 
preparation of lessons. On the one hand, this enabled her to adapt the teaching to her individual 
approach and to the students. On the other hand, the researcher had even less control of the actual 
implementation of the innovation, and the risk of non-intended realization increased (significantly).

Implementation support strategies: As suggested by Century and Cassata (2016), several theoretically 
based formats of support were included to assist the teacher in the implementation process. For 
example, the ‘whys and hows’ related to the concept of reflection were thoroughly discussed to 
enhance the teacher’s principles-knowledge—a strategy that seemed to benefit their experience of 
relevance, as seen in Gregersen et al. (2019). These support strategies were further developed during 
the study. Central to the cooperation between researcher and teacher was the shared planning and 
evaluation sessions. In our case, the planning not only included discussions and clarification of focus 
and main purpose of the lesson (principles-knowledge), but also a description of the lesson’s activities 
and their individual purpose (how-to knowledge). This kind of detailed planning had not previously 
been conducted in cooperation with the researcher, but an increased awareness of the challenges 
connected to the implementation had led to this initiative from the researcher, which was welcomed 
by the teacher. Likewise, the described case became the cause of further adjustments of the support 
strategy, eventually including shared preparation and considerations of potential student responses 
and appropriate teacher reactions.

When these three influential factors are compared and connected, interesting issues related to the 
implementation process are revealed. Firstly, the attributes of the innovation define the teacher as an 
expert on practice, thus making her responsible for the realization of the intention. However, the 
characteristics of this specific teacher make this realization unpredictable. In addition, the support
strategies intended to account for this problem are complicated by the allocation of expertise between the teacher and the researcher. A possible dilemma occurs when deviations from the intention that are observed in the teaching are to be addressed in the evaluation. It is, on the one hand, essential to the success of the innovation that the intention be realized. On the other hand, the communication between researcher and teacher must remain respectful of their respective areas of expertise while at the same time supporting and benefiting future cooperation and innovation. Addressing problematic issues related to practice thus becomes a difficult act of balance. In this case, the evaluation session led to adjustments in the support strategy that increased the explicitness of the innovation, thereby changing its attributes and affecting the level of the users’ autonomy. Studying the influential factors of this case clearly illustrates that the attributes and overall goal of this innovation may to some extent be incompatible. The goal of developing the students’ beliefs through teaching principles may demand a change that is too ambitious in terms of the culture of practice—the influence of which was at first hand underestimated by the researcher. For example, this case shows how the implementation of opportunities for reflection is hindered by a gap between the intentions of the researcher, the apparent intentions of the teacher, and what is practically possible within the context of the culture of practice and the teacher’s how-to knowledge. Returning to the research question, it is clear that IR constructs do have something to offer our qualitative case study in terms of explanatory power to the lack of mutual understanding between researcher and teacher. The IR analysis made it clear that when the innovation is not specific or explicit enough, then the implementation of it is proportionally dependent on the characteristics of the end-users. This should be dealt with both in the innovation design and in the support strategy.

References


