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A comparison of the implementation of two large-scale innovations in mathematics education: TRIUMPHS and ‘Boost for Mathematics’

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When evaluating large-scale innovation implementation projects, it is of particular interest to identify which characteristics determine the innovation’s impact on the target group. By analyzing the projects TRIUMPHS and Boost for Mathematics (BM) by their respective designs of professional development and their designs for scaling innovations, we identify influential factors that appear to have been decisive in terms of these innovations’ different impacts. We found that TRIUMPHS’ relative success, compared with the BM, may rest on voluntary participation, flexibility in innovation enactment, in terms of fidelity and adaptation, and a scaling plan resting on the teachers seeking out the innovation rather than the innovation being mandatory for the teachers.

Keywords: Implementation research, scaling, PD, Boost for Mathematics, TRIUMPHS.

Introduction

Why are some innovations effective and successful in their implementations, while others are not—or are only so to a lesser extent? Of course, there is no simple answer to this question. Many factors play a part in the successful implementation of an innovation. In addition, both the major successes and the lesser ones have likely gone through a long preparation phase prior to the implementation, and the larger the initiative the more experts were probably involved, which one would think should increase the chances of success. In this paper, we take a comparative look at two large-scale innovations in mathematics education. The common basis for the innovations is that they both have to do with the professional development (PD) of mathematics teachers. Besides this, they are rather different: one is aimed at US college and university instructors, who participate on a voluntary basis in a project centred around the use of primary historical sources in the teaching and learning of mathematics; the other was a national effort for Swedish K-12 teachers centred around a large variety of PD modules, and where participation was mandatory if a principal signed up a school for participation. Still, it is our hypothesis that a comparison of key aspects of the two innovations and their implementation processes may reveal insights in terms of, for example, attributes of the innovations or determinants, core ideas, of the implementations that acted as catalysts for either success or failure. This in particular if the two innovations and their implementations are analyzed through the same theoretical lenses. That said, it appears to be commonly acknowledged that the US project, named “The *TR*ansforming Instruction in Undergraduate Mathematics via Primary Historical Sources”, and abbreviated TRIUMPHS, is a relative success (Barnett et al., 2022), whereas the Swedish effort, known as the “Boost for Mathematics”, we abbreviate it BM, was less successful in several respects (e.g., Lindvall, 2018).

Our theoretical lenses to compare these two innovations and their implementation processes are Kennedy’s (2016) classification of PD programs and Coburn’s (2003) four dimensions of scaling.

Our specific research question is: *From a theoretical point of view on PD and scaling, what are the influential factors of TRIUMPHS and BM, respectively, that appear to have been decisive in terms of these innovations' different impacts?* We begin by describing the theoretical constructs in detail, after which we provide descriptions and analyses of TRIUMPHS and BM, respectively. We end the paper with a discussion on influential factors and differences between the projects in terms of the organization of PD and scaling, and finally a conclusion.

Implementation research theoretical constructs

PD programs for teachers come in different shapes based on different ideas on how to achieve change in classroom practice. We use Kennedy's (2016) classification of PD designs, *prescriptions*, *strategies*, *insight*, and *body of knowledge*, to describe the differences between TRIUMPHS and BM. In Kennedy's classification, *prescription* refers to the PD model based on scripted instructions for teachers to follow. Teachers are given a 'recipe' for how to act in the classroom. From this so-called profidelity perspective (Century & Cassata, 2016), the idea is that the better the teachers follow the recipe, the better the outcome of the implementation is expected to be. While the profidelity perspective dominates the prescription model, less prescriptive models of PD need other perspectives. The pro-adaptation perspective is based on the idea that adaptations of innovations are both necessary and desirable. What is important is the outcome of the innovation.

Facilitating teacher learning through the PD model *strategies* in Kennedy's (2016) classification includes presenting a goal and demonstrating practices to achieve that goal. Teachers are given certain agencies to choose different strategies from 'toolboxes' to address specific goals for practice, e.g., a problem-solving strategy, a method for organizing classroom discussions, or a new trajectory for presenting content. While teachers' autonomy is given some space in the strategy model, which we interpret as a certain degree of pro-adaptation perspective, profidelity dominates once a strategy is chosen.

The third classification, *insight*, rests on the idea that increased knowledge exemplified by teaching practices can give teachers tools to change their practice (Kennedy, 2016). The model is based on challenging the teachers' beliefs so that they are given incentives to change their practice via their own 'AHA moments'. The degree of pro-adaptation perspective is significantly higher in this model than in the strategy model. Here, the PD model aims at changing the teachers' understanding of the classroom situation and then acting on the new understanding with a changed practice.

The fourth classification, *body of knowledge*, carries the idea that if teachers just gain more mathematical knowledge for teaching, pedagogical content knowledge, didactics, etc., they will be able to plan and implement better teaching (Kennedy, 2016). Body of knowledge can for example be regular university courses, lectures, or tutorial videos which are used as 'watering jugs' of knowledge to pour over the teachers. To a greater extent than the other models, prescription, strategy, and insight, this PD model rests on a pro-adaptation perspective of the implementation of innovations. The four classifications are not mutually exclusive. PD programs may contain elements from all four models.

Addressing the task of disseminating innovations, Coburn (2003) presents four interrelated dimensions of scale: *depth*, *sustainability*, *spread*, and *shift in reform ownership*. *Depth* refers to a

change in classroom practice that goes beyond a shift in curriculum resources and the introduction of specific teaching methods and activities for teaching. Coburn (2003) argues that scaling in depth includes a shift in teachers' beliefs and norms of social interaction regarding communication and pedagogical practices in the classroom. The underlying ideas of what constitutes effective instruction and how the students shall learn may need to change for the implementation project to succeed.

Implementation projects need a plan for how the innovation will survive in the organization after the implementation project is finished. The dimension of scaling that Coburn refers to as *sustainability* concerns the scaffolding that is left to maintain the vitality of the innovation after the support of the reform leaders is withdrawn from the organization (Coburn, 2003).

While *spread* to other schools and classrooms is key in all scaling, Coburn includes spread within the different levels of stakeholders in the school system: classrooms, schools, and districts (for more information, see Krainer, 2021). Finally, Coburn adds the dimension of a *shift in reform ownership* to the notion of scale. When an innovation is launched, the ideas and activities are owned by the innovators and implementation designers. But over time, the authority to scale the implementation needs to shift to the districts, schools, and teachers if the innovation is to become a natural part of the organization. Then scaling in-depth, sustainability, and spread can be maintained.

The TRIUMPHS project

The *TRansforming Instruction in Undergraduate Mathematics via Primary Historical Sources* (TRIUMPHS) project is an American endeavor funded by the National Science Foundation (NSF), and one that draws on previous projects and experiences using primary historical sources from the history of mathematics in the teaching and learning of mathematics (Barnett et al., 2022; Clark et al., 2022). The innovation is built around so-called primary source projects (PSPs), which involve a special strategy of bringing the primary sources into play as part of curricular materials and reporting on the expected benefits of using this teaching approach. This is to say that on the one hand, TRIUMPHS is a development project implementing an innovation. Yet, on the other hand, it is also a research project related to students' understanding of mathematics, to a large extent relying on Sfard's (2008) theory of commognition.

The primary historical sources can be excerpts from published manuscripts (in books or journals), letter correspondences, etc. by past mathematicians. For example, these might cover the history of the concept of function, and the various, previous 'concepts' around, e.g. that of Leonhard Euler (1707-1783), or (as in previous TRIUMPHS related projects) the development of abstract algebra involving works of mathematicians such as J. L. Lagrange (1736–1813), Augustin Cauchy (1789–1857), and Arthur Cayley (1821–1895). The PSPs present parts of chosen primary sources (English translations, if originally in other languages) accompanied by a so-called 'guided reading', the purpose of which is to provide background to the text, supplementary comments if the terminology is different from that which the students are familiar with, and exercises and tasks assisting the students' understanding of the involved mathematical content.

The PSPs are designed for undergraduate students and the target groups are their college and university instructors. The PSPs are intended as a replacement for traditional textbooks or lecture notes. They are designed for the same number of course days as the traditional material. They are

self-contained in terms of mathematical and historical content. A special feature of the PSPs is that these can be ‘altered’ as part of the adaptation by the instructors if needed, or if the teachers simply have an urge to do so. Hence, the PSPs are no-cost, open-source LaTeX files. College and university instructors, who usually hold a mathematics-related degree, are invited to participate in specially designed training seminars, where PSPs are presented by their authors and where certain ‘site-testers’ (authors or instructors) share their experiences with using the various PSPs. Over time, some of the instructors who gain experience with the use of primary historical sources may end up developing their own PSPs (e.g. under the guidance of project leaders).

According to the project leaders of TRIUMPHS, the innovation is aimed at an ‘implementation at scale’, i.e., the idea of expanding the innovation to new contexts that are larger than the initial in terms of the number of undergraduate students, instructors, colleges and universities, districts, etc. (Barnett et al., 2022). In relation to TRIUMPHS, it should be emphasized that any participation is voluntary on the instructors’ behalf. In their discussion of factors related to attributes of the PSPs, including also the project’s dissemination and implementation support strategies, Barnett et al. (2022) point to different characteristics of the individual instructors, and that these are of two types: “those who have thus far limited their PSP usage to a single course and those for whom PSP usage has permeated their instructional practice” (p. 208). In terms of any actual ‘impact’, Barnett et al. (2022) describe various positive experiences, both in terms of quantitative and qualitative measures. In relation to the latter, Barnett et al. draw on Coburn’s (2003) measures of depth and shift in reform ownership—things that truly show, once the second type of instructors begins to adapt existing PSPs to their own practice, or even develop their own.

The BM project

The *Boost for Mathematics* (BM) project was an in-service training program for Swedish mathematics teachers, covering K-12. It ran between 2013 and 2016. A total of 76% of all Swedish mathematics teachers joined the large-scale BM project. While it was voluntary for principals to join the BM, the school's teachers had no choice whether to join or not once the principal had decided. The background of the project was the fact that Swedish results in international large-scale assessments had decreased very much in the previous 15 years. Actually, no other country has had a greater drop in these types of studies (e.g., TIMSS and PISA). This triggered politicians to act. In the official reports preceding the BM, a plausible cause was identified: the teachers were too seldom leading the teaching, and students were too often working alone without supervision and feedback from the teachers. This resulted in the general goals of BM concerning a changed teaching culture, but also a changed in-service training culture. As to the teaching culture, teachers should know more teaching methods and learn how to reflect better on decisions linked to teaching (Prytz, 2021). BM can in certain respects be considered a top-down project, since it was initiated by the national government and later on organized by the National School Agency (*Skolverket*).

BM covered large parts of the mathematics curriculum. There were so-called modules, used by the teachers, for each of the specific topics of arithmetic, geometry, algebra, and functions. There were also modules for the topics of problem-solving, digitalization, and language in mathematics. For all of these topics, there were modules dedicated to four-year spans: 1–3, 4–6, 7–9, and 10–12. For

kindergarten, schools for students with learning disabilities, and adult education there were specific modules. Swedish researchers in mathematics education were involved in producing all the modules (Prytz, 2021). In each participating school there was one or more expert teacher(s) who led the peer learning sessions based on the modules. The sessions for each year span were based on two of the modules mentioned above. The one on arithmetic was mandatory, the other was optional. The expert teachers were experienced teachers who got an eight-day training at the university by researchers in mathematics education (Prytz, 2021).

As to the modules' specific content, they all comprised four themes: abilities (c.f. competencies), formative assessment, interaction, and socio-mathematical norms. The modules were distributed through the website of the National School Agency. More concretely, the modules contained films, audio clips, and web texts with instructions and questions for the peer learning sessions. Each module also contained two types of scientific articles: an international overview of each topic and the four themes and specific articles about the same matter in a Swedish context (Prytz, 2021).

Discussion and analyses

As data sources, we referred to three recent journal publications for each project, namely: Barnett et al., (2022); Can and Clark (2020) and Clark et al., 2022 for the TRIUMPHS project and Helenius (2021); Lindvall et al., (2022) and Prytz (2021) for the BM project. An overview of the two projects in terms of design is given in Table 1. We then analyzed the two projects using the two frameworks of Kennedy's PD model and Coburn's scaling dimensions. We present our analyses below.

Table 1: A design comparison of TRIUMPH project and BM project

	TRIUMPH project	BM project
Scaling	medium scale	large scale
Participants (target group)	133 college and university instructors of mathematics courses (Clark et al., 2022)	76% K-12 mathematics teachers in Sweden (app 40 000 teachers (Boesen et al., 2015. p. 129))
Participation	Voluntary basis	Teachers have no choice if the principal decided to participate
Resources	Freely available via Digital Commons open-source with LaTeX codes for instructors who wish to modify	Freely available on the website of the National School Agency modules including tasks, reading materials, videos, etc.

BM is clearly a large-scale implementation since it was a nationwide curriculum reform (Aguilar et al., 2023). According to Aguilar and his colleagues' (2023) classification, the TRIUMPHS project can be most likely, considered a *deliberate multiplier* type of medium-scale implementation project. In addition to the difference in scale, the two projects are diverse in the end users—tertiary level instructors vs K-12 teachers. Undoubtedly, the designs of the implementations were guided by the end users being tertiary vs K-12 and likely makes a considerable impact on the level of success of

each project. For instance, often, tertiary-level instructors have more autonomy to select the course/s to teach and the methods of teaching them (Barnett et al., 2022) than K-12 teachers. This disparity is visible in the participation in the projects. Although the participation was on a voluntary basis in both TRIUMPHS and BM, participant teachers of BM had no choice if their principals chose to participate. In contrast, in the TRIUMPHS the instructors were free to choose to adopt the PSPs in their teaching. The difference in motivation in participation could likely be an influential factor in the success of the TRIUMPHS project.

BM's goals fit well with Kennedy's (2016) PD models of strategy and insight. The openness of the goals was reflected in the organization of BM. It was based on an idea about peer learning among teachers, which took place in the schools. If the goals of BM, its organization, and the modules are put together, the project has clear similarities with Kennedy's (2016) strategy model. The teachers were given agency (through peer learning) to choose methods from a toolbox (the modules) to solve specific goals. This also fits nicely with Coburn's (2003) scaling dimension denoted "shift in reform ownership", at least in theory. The formative assessment theme could fit Kennedy's (2016) prescription model, since it involves a routine for how assessments are used. However, the peer learning format of BM, giving teachers more agency, takes away the prescriptive character.

While TRIUMPS are delivered through the PD model *strategies*, BM is carried by both the *strategies* and the *insight* PD models. Since the strategies- and insight models are quite close to each other, there are similarities in the design for implementing the two innovations. Both TRIUMPS and BM require profidelity and pro-adaptation of innovations but in slightly different ways. One can use TRIUMPS' no-cost, open-source, PSPs with a full profidelity enactment in practice. Yet, teachers can also develop their own PSPs, which is a clear pro-adaptability perspective on the enactment of the innovation. There are thus opportunities for the teachers to use the innovation as it suits them without violating the program determinants—something that can be a factor in facilitating good results from the implementation. The BM, on the other hand, often required profidelity to teaching models, like the above-mentioned formative assessment, and sometimes left the teacher with fewer prescriptions and greater responsibility for a pro-adaptation perspective on the implementation of the innovation, as in the example of peer learning. This breadth of demands, to follow certain recipes on the one hand and act with autonomous agency in classroom practice on the other hand, may have been challenging for the teachers and limited their opportunities to follow the determinants of innovation. Considering the two innovations through the lens of Coburn's (2003) dimensions of scaling, clearly BM was *spread*, since 76% of school mathematics teachers joined the project. Although the TRIUMPHS project is not widespread on a national basis, when compared with the BM, over time it has spread to a larger group of instructors, teachers, and students. Hence, each project can be linked to the *spread* dimension of Coburn's (2003) scaling. The difference, however, is that participation of the instructors in TRIUMPHS is on a voluntary basis, whereas in the BM project this was a decision made by the principals of schools. Hence, technically, participation in the BM project was on a voluntary basis, but in practice it was not so. In TRIUMPHS, the instructors who volunteered to participate joined the project because they are willing to adopt the PSPs in their teaching. In contrast, at least some of the teachers were not very keen to change their teaching style to the new methods introduced in the BM. This might be one reason why TRIUMPHS appears more successful than BM, i.e., due to the

attributes of the users. Since the participants of TRIUMPHS were self-motivated and already convinced to use the PSPs, the impact might have appeared faster than for the BM.

Each project has components linking to the *depth* dimension of Coburn's (2003) scaling. However, the expansion of context in the TRIUMPHS project is different from the focus of the BM project. From the beginning, there were innovations *in* the modules as well as among the modules in the BM, whereas the expansion of the context happened in the TRIUMPHS project over time. The nature of the curricular materials of TRIUMPHS—space and freedom for the user to make changes and adapt to their needs—provided opportunities for the instructors to design their own materials for other mathematics courses. The instructors, first, modified the available resources and once they were familiar with the PSPs, they could design new PSPs. This has happened over time, when the users were familiar with the approach of PSPs in understanding modern mathematics. In addition to the expansion of the context, the ownership of the PSPs also shifted to the instructors, i.e., the *reform ownership* dimension of Coburn's (2003) scaling dimensions. The BM project also drew on the shift in reform ownership by providing the agency to choose the method of teaching from the given methods in a toolbox. Although each project provided some agency for their users, in comparison, instructors who joined TRIUMPHS had more freedom to adapt the materials than BM teachers. This might be a reason for the positive impacts of students' achievement of TRIUMPHS (e.g., Can & Clark, 2020) as opposed to the BM (e.g., Lindvall et al., 2022).

Final remarks

In this paper, we have analyzed and discussed whether the differences between the successful TRIUMPHS and the less successful BM can be framed in their differences in PD design and plan for scaling innovation. We asked the question: *From a theoretical point of view on PD and scaling, what are the influential factors of TRIUMPHS and BM, respectively, that appear to have been decisive in terms of these innovations' different impacts?* We found differences in the deliverance of the innovations both in terms of the planning for scaling, and the design of PD projects that brought the innovations out to the teachers and classrooms. Our comparisons of course also raise new questions, some of which have to do with our choice of theoretical constructs. For example, in relation to the notion of depth, it appears rather difficult to assess any profound and consequential change in the BM, at least beyond any surface structures and procedures. To truly assess this, follow-up studies on the involved teachers' potential change in beliefs towards their teaching, pedagogical principles, etc. would have been helpful. However, at present such do not exist.

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