IMPLEMENTING RESEARCH RESULTS IN TECHNOLOGY INDUCED TEACHING OF STATISTICS – A LITERATURE REVIEW

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Implementing research results to school practice with a high level of fidelity is a big challenge for the research community in mathematics education. Technology induced teaching of mathematics adds further challenges to such issues since it is an area where many teachers are unexperienced. In this paper, we report on a literature review based on papers published in SERJ and which reports on studies involving the investigation of a technology induced intervention. The review is guided by a newly developed framework, which provides dimensions for analyzing issues argued to be crucial in implementing research results. Based on results of the literature review I discuss themes for developing research on technology induced teaching of statistics to face challenges in the implementation of the research results in the practice.

INTRODUCTION

In Sweden, the law mandates that teachers are to plan their teaching on scientific basis and proven experience (SFS 2010:800). There is a strive from the practitioner's point of view to implement mathematics education research results to inform practice as well as there is a strive from the researcher's point of view to see results implemented. However, the present gap between research and practice has been confirmed and extensively discussed (e.g. Burkhardt & Schoenfeld, 2003 and McIntyre, 2005). McIntyre (2005) as well as Burkhardt and Schoenfeld (2003) suggests ways of bridging the gap, by moving research and research designs closer to the practice it intends to inform. All in the purpose of informing action. Frameworks and theories with the purpose to inform teachers' actions have gained attention with the recent years of educational design research (e.g. McKenney & Reeves, 2012).

Nilsson, Ryve and Larsson (2017) differentiate between different types of theories for teacher action depending on whether they mostly prescribe teacher action or sensitize teachers to critical issues during a lesson. Frameworks that primarily sensitize an actor highlights theoretical underpinnings and critical issues whereas frameworks that prescribe specific actions tend to focus less on theoretical connections and more on practical course of actions (Ruthven et al., 2009). Frameworks that indicate to teachers what to look for seems to strengthen their current practice, helping them make decisions based on what they pick up in the classroom. Frameworks that prescribe action seems to help teachers reorganize their practice according to a given teaching strategy or task. The prescriptive or sensitizing nature of research results appears important to consider in collaborations with teachers (Nilsson, Ryve, & Larsson 2017) and further more when research results are to be implemented by teachers. Even though Nilsson, Ryve and Larsson (2017) refrain from being normative, the question is what these identified categories mean for the rapid development of technology induced mathematics teaching?

The aim of this paper is to discuss the basis of implementation of research results in statistics education results within the context of technology induced mathematics teaching. Particularly how is the scientific basis available to inform practice packaged within the context of technology induced mathematics teaching? By working towards fulfilling such aim I provide insight on the challenges and opportunities for teachers to implement classroom-based research results with a high level of fidelity when teaching statistics with the use of digital technology.

RESEARCH ON TECHNOLOGY INDUCED MATHEMATICS EDUCATION

The access to devices and digital technology is increasing rapidly in many parts of the world, and so too in the mathematics classrooms. As digital technology becomes more or less a natural part of everyday life, ongoing educational research provides insights into how it can be utilized in the classroom to enhance students' learning. So far, there seems to be great potential for strengthening the teaching and learning of mathematics with digital resources (e.g. Drijvers et al., 2016; Joubert, 2013), at least on a hypothetical level.

Meta studies, analyzing quantitative studies focused on mathematics education, indicate that integrating technology in the everyday teaching of mathematics in general have a positive effect (Cheung & Slavin, 2013; Li & Ma, 2010; Slavin & Lake, 2009). Whatever the reason, students seem to learn more compared with control groups. However, the PISA 2012 report indicates that an increased use of digital technology might have the opposite effect (OECD, 2015). The type of integration seems to be important, big reorganizing projects that substitute the curriculum with new technology-based ones are less effective than small content-specific activities (Swedish Institute for Educational Research, 2017).

Within the field of statistics education, the uncertainty of the impact of new technology in the classroom was observed early on (Mills, 2002). Even though small-scale research has shown potential for enhancing students' learning of difficult and abstract statistical concepts the research field is not unanimous. There has been a lot of publications on the matter since then, highlighting the potential for technology to bridge the gap between data and conclusions through simulations and fast graphical representations (Biehler, Ben-Zvi, Bakker, & Makar, 2013). Biehler, Ben-Zvi, Bakker and Makar (2013) calls out for more insight into task design when using new technology to further ensure that the potential is put to use in the practice, but also more insight into how teachers can be supported to use new statistics technology in their classrooms.

Utilizing technology to enhance students' learning in mathematics is a big challenge for teachers (Drijvers, 2013; Drijvers, Ball, Barzel, Heid, Cao, & Maschietto, 2016). Teachers need to learn the software, but also learn how to organize a mathematics classroom with the added complexity of using technology (Biehler, Ben-Zvi, Bakker, & Makar, 2013). To conclude, teacher action is essential for the implementation (e.g. Drijvers, 2013; Swedish Institute for Educational Research, 2017). The question is how scientific results aiming to inform practice, are packaged within the context of technology induced statistics teaching?

METHOD

The selection of papers included in the analysis is from the IASE and ISI's journal Statistics education research journal. Much like current conferences summon the research community and could potentially be representative for that specific research field (Joubert, 2013), I argue that a specialized journal such as the Statistics education research journal could also be viewed as a sample representative for the statistics education research field. The journal's review process might be more selective than that of a conference, but in return it allows more room for the authors to expand on their results. More in-depth result sections enabled me to characterize these results in terms of implementation. With the use of search strings in indexed titles, abstracts and key words an initial sample of 36 papers was selected for full text screening. Inclusion criteria were result sections with technology induced intervention in elementary school settings or papers discussing such interventions. The final sample consisted of 14 papers that met the inclusion criteria.

For the analysis, a recently presented framework (Nilsson, Ryve, & Larsson, 2017) was used to characterize results from each paper in terms of supporting teachers' actions in mathematical classroom practices. Four categories were used from the framework, how the results generate *the role of the teacher*, whether they *prescribe teacher action or sensitize teachers*, the kind of *teacher learning* they demand and whether the results *strengthen or reorganize ongoing practices*. In addition to these four, a fifth category on *the role of technology* was formed prior the analysis. It adheres to the unique features and impact technology potentially has on mathematical classroom practices. As Joubert (2013) argues, technology's role in student's learning of mathematics has been a theme in mathematics education research and would hence be of high interest for at practitioner who wants to implement specific research findings. Each category was used as an analytical question, to be answered by the texts themselves, and summarized into themes with the words of the original authors as far as possible. When the sample was analyzed, conclusions were cautiously generalized in relation to other literature reviews from research on technology induced mathematics education.

RESULTS

Table 1 summarize the themes from the analysis as well as the absolute frequency of the occurrence of each theme in the sample of papers. Some papers did not answer the analytical questions; hence the frequency does not add up to 14 in each case. Some papers could have fitted within more than one theme, put was only counted once according to the most prevalent theme in respective paper.

Table 1. A summarization of the results of the review, notice that some categories does not add up to 14 since not all papers answered each analythical question.

On the role of teachers in the classroom	On the role of technology	Prescribing teacher action or sensitizing them	Demands on teachers and teacher learning	Strengthening or reorganizing practice
Teacher as an organizer (4) Teacher as an actor in interaction (3) Teacher as a promoter (3)	Tool for visualization (5) Tool for simulation (4) Tool for mediation of conceptual understanding (2) Tool for provoking reflection (4)	Prescribing (7) Sensitizing (7)	Use of the tool (2) Teaching strategy (2) Statistical concepts linked to the task (1)	Strengthening (5) Reorganizing (9)

Out of 14 papers, only 5 discussed the demands put on teachers, or the learning necessary to implement the tasks presented in the papers. The result is interesting, especially when thought of in relation to the right most category. A majority of the papers indicate that the teacher, at least in the context that the studies was performed, was to reorganize its practice to implement the research results. The papers opted for a reorganization in two aspects, content and teaching strategy. Some argued that the use of technology makes content previously thought of as unsuitable accessible for a new group of students. Other papers argued for a specific teaching strategy and role of the teacher to implement the results with a high level of fidelity.

There was an interesting lack of coherence between the categories, papers with the teachers as actors in interaction were all sensitizing in nature. Meaning there was little or no effort made to describe how to act in different situations, which could enable a high level of fidelity of implementation. In the opposite case, with teachers as promotors, papers had a prescriptive nature. The prescriptive nature somewhat goes against the idea to position the teacher as a promotor, one might expect results to inform/sensitize the teacher on what to look for and encourage in their role.

The analysis revealed a notable coherence between the role of the teacher and the role of technology. Most papers took into account, explicitly or implicitly, how the teacher and the technology had complementing roles to enhance students' learning. Where the technology was conceptualized as a tool for provoking reflection, the teacher was thought of in a more withdrawn role of a promotor or organizer. When technology was used as a simulation tool for students to gain experiences of statistical processes and concepts, the teacher was thought of as an actor in interaction with the students.

CONCLUSION

The ways in which results from technology induced statistics education is packaged can be improved to increase the possibility of implementation with high fidelity by teachers. Previous research indicates that the teacher's experience with technology induced teaching of mathematics is key (and a big challenge) for positive results in regards to students' learning (Drijvers, 2013; Drijvers, Ball, Barzel, Heid, Cao, & Maschietto, 2016). Meanwhile the analysis of the sample of papers indicates a lack of discussion about the demands put on teachers, in line with Biehler, Ben-Zvi, Bakker and Makar's (2013) call for more research on the subject.

If we strive for an implementation with a high level of fidelity of research results in the field, the results of this paper suggest three themes for developing research on technology induced teaching of statistics: 1) to include a discussion, e.g. in the implementation section, about the basic demands the research results put on teachers, 2) to be aware of the suggested role of the teacher in relation to the types of results presented, and 3) develop results where the complementing roles of teachers and technology is explicit.

NOTES

Titles of papers analyzed in the sample were *Interactive visualizations and statistical literacy; Developing statistical literacy in the final school year; Probability from a socio-cultural perspective; Conceptual issues in quantifying unusualness and conceiving stochastic experiments: insights from student's experiences in designing sampling situations; Students' informal inference about the binomial distribution of "bunny hops": a dialogic perspective; Students' expressions of uncertainty in making informal inference when engaged in a statistical investigation using tinkerplots; Reasoning about shape as a pattern in variability; Exploring beginning inference with novice grade 7 students; Teaching probability with the support of the R statistical software; Making comparisons between observed data and expected outcomes: students' informal hypothesis testing with probability simulation tools; Local and global thinking in statistical inference; Developing young students' informal inference skills in data analysis; The role of causality in the co-ordination of two perspectives on distribution within a virtual simulation; Strategies for managing statistical complexity with new software tools*

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