Fonds de recherche
Société et culture
Québec

Rapport de recherche

PROGRAMME ACTIONS CONCERTÉES

Environnements d'apprentissage technologiques : augmenter la motivation, l'auto-régulation et la réussite scolaire des étudiants à l'aide de l'apprentissage par l'enseignement

Chercheure principale

Krista Muis, Université McGill

Cochercheure

Susanne Lajoie, Université McGill

Collaboratrices

Rhiannon Sparkes, Commission scolaire Lester B. Pearson
Cathy Roberts, Commission scolaire Lester B. Pearson

Établissement gestionnaire de la subvention

Université McGill

Numéro du projet de recherche

2014-RP-178947

Titre de l'Action concertée

Persévérance et réussite scolaires

Partenaire(s) de l'Action concertée

Le ministère de l'Éducation et de l'Enseignement supérieur (MEES)
et le Fonds de recherche du Québec - Société et culture (FRQSC)

RÉSUMÉ

Learning by Teaching: Fostering Self-Regulatory Strategies and Achievement during Complex Mathematics Problem Solving

Research Questions and Hypotheses

We conducted three studies to examine whether learning by teaching increased elementary students' motivation for learning, positive emotions, self-regulatory strategies, and problem solving achievement compared to solely learning for learning during complex mathematics problem solving. Across these studies, we used different types of learning by teaching approaches: learning by preparing to teach for Study 1, learning by teaching and learning by preparing to teach for Study 2, and learning by teaching a teachable agent for Study 3. For the first two studies, students used various iPad applications to solve the problem and, for the third study, we developed an iPad app that embedded the problem, concept mapping feature, and teachable agent component within the app. Our research questions were as follows: (1) Do students' task definitions differ when learning by teaching compared to learning for learning? (2) Are there differences in motivation and emotions when learning by teaching versus when learning for learning? (3) Are there differences in the frequency of self-regulatory strategies, such as planning and goal setting, cognitive strategies, and metacognitive strategies, when solving a complex mathematics problem when learning by teaching compared to learning for learning? (4) Does learning by teaching result in higher levels of mathematics problem solving achievement compared to learning for learning? (5) Does gender moderate the effects of learning by teaching on the various outcomes?

To answer the first research question, students were asked to create a concept map using *Popplet* (a tablet app) that included four features: blue for the title, red for the first step to solve the problem, black for important information, and green for calculations needed to carry out the problem. We hypothesized that students in the learning by teaching condition would include more important information about the problem in their concept map and would hierarchically structure the information better (i.e., green calculations subsumed under related important information or vice versa) than students who were asked to just solve the problem. To address the second research question, each day that students solved the problem, they completed self-reports designed to measure their value for learning mathematics, perceptions of control for learning (action control and outcome control), and the emotions they experienced during learning. We hypothesized that students in the learning by teaching condition would report more value, more control and more positive emotions but higher anxiety compared to students in the learning condition.

To answer the third research question, for Study 1, self-regulatory processes were captured via a think aloud protocol (i.e., students were asked to think out loud as they solved the problem and their voices were audio-recorded, transcribed, and then coded for various learning strategies). For Studies 2 and 3, students self-reported the learning strategies they used to solve the problem and, for Study 3, the teachable agent app traced students' learning processes as they constructed their concept maps and taught their agent how to solve the problem. We hypothesized that, because of the different learning conditions, students should develop different task definitions, which should theoretically result in variations in planning and goal setting. That is, if students define the task as one in which they need to develop a good understanding of the problem to be able to explain to others how to solve it, then these individuals may plan to use more metacognitive strategies to ensure sufficient progress and understanding compared to students who are told to simply solve the problem. Students in the teaching condition may also set more goals, like ensuring their work is done well, compared to students who just solve the problem. Based on differences in planning and goal setting, differences should also arise during the enactment and evaluation phases of learning wherein various cognitive and metacognitive strategies are employed. As such, we hypothesized that students in the learning by teaching conditions would engage in more planning and goal setting, and use more cognitive and metacognitive processes during problem solving compared to students in the learning condition.

For the fourth research question, given that conceptual understanding of the problem and metacognitive processes are central to successful mathematics problem solving, we hypothesized that students in the learning by teaching conditions would have a higher achievement score on the complex mathematics problem compared to students who just solved the problem. Finally, for the fifth question, given previous research, we hypothesized that girls would experience more anxiety, but engage in more self-regulatory processes compared to boys. As a result of the difference in self-regulatory strategies, girls should have a higher achievement score on the mathematics problem.

Results

The first research question addressed whether there were differences in students' understanding of the problem as a function of learning condition, controlling for prior knowledge. Across all three studies, consistent with our hypotheses, students in the learning by teaching conditions developed a more detailed and better conceptually organized concept map compared to students in the learning condition. For Studies 1 and 3, girls developed a better concept map than boys. For emotions and motivation, across all three studies, no differences were found between learning conditions, but girls reported higher levels of anxiety than boys. For self-regulatory strategies, results revealed that students in the teaching conditions used more metacognitive and planning strategies compared to students in the learning condition. For Studies 1 and 3, girls used more planning and goal setting, and metacognitive strategies than boys. For Study 2, boys used more planning strategies than girls. Finally, for problem solving achievement, students in the teaching conditions performed significantly better on the complex problem compared to students in the learning condition. For Studies 1 and 3, girls outperformed boys on the complex mathematics problem. These results suggest that, in the context of complex mathematics problem solving, when learning by teaching focuses specifically on explanation, students develop a better understanding of the problem, use more learning strategies critical for problem solving, and perform better compared to students who are told to simply solve the problem.

Project Context and Background in Conjunction with the Call for Proposals

Digital technologies are ubiquitous and are being used in nearly every facet of everyday life. Despite the large number of tools that are available today, educational institutions have not fully integrated these technologies into classrooms in ways that can support learning. How might technologyrich learning environments (TREs) be designed to support learning? Broadly, our primary research questions address the call to examine the benefits related to the use of new technologies into classrooms, as well as their impact on achievement. Specifically, we explored how TREs enhance students' mathematics problem solving at the elementary educational level. Additionally, given the gender differences typically found in beliefs towards mathematics problem solving, we examined whether TREs can reduce those gender differences by varying the learning environment. Our research focused on the following priorities and needs: What are the effects of TREs on students' motivation, engagement, and achievement? What role does gender play in moderating the effects of TREs? We empirically evaluated how students' motivation, emotions, learning processes, and learning outcomes varied across different TREs in the context of mathematics problem solving.

Our research addressed each of the major objectives in the call: (1) Examined the benefits related to the use of new technologies in classrooms; (2) Considered gender differences; (3) Promoted partnerships with teachers and schools; and, (4) Promoted dissemination of results for teachers and schools involved. For Objective 1, we advanced research and theory on how TREs can be developed to enhance elementary students' motivation, engagement, learning processes, and achievement in the context of mathematics problem solving (Research Priority Axis 5.1). For Objective 2, we considered whether gender moderates the effects of different TREs on students' motivation, engagement, and learning processes and outcomes. For Objectives 3 and 4, we established formal partnerships with teachers and schools to carry out the proposed work. By establishing formal partnerships, we brought innovation into classrooms through teacher training and knowledge transfer. Our goals were to improve student learning outcomes, inform policy, and guide future initiatives with regard to the implementation of these technologies into classrooms. Our partnerships provided the foundation for us to realize these goals. Indeed, the research we conducted in the schools provided empirical support for the integration of a one-to-one tablet program at Dorset Elementary School, the first in the Lester B. Pearson School Board to do so.