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Comparing male and female students' self-efficacy and self-regulation skills in two undergraduate mathematics course contexts

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Students' efficacy beliefs have a positive influence on students' academic achievement and retention, especially for female students. These beliefs are closely linked to students' ability to regulate their learning. In this quantitative study, students' self-efficacy and self-regulation of learning are compared in two university mathematics courses that differ in content but also in their pedagogical setting: one is a more traditional lecture-based course, and the other course is taught with the Extreme Apprenticeship (XA) method. The analysis is based on the same cohort of students in the two contexts (N=91). The results suggest that students have higher self-efficacy levels in the course using the XA method. Also, the XA course seems to diminish some gender differences present in the more traditional course setting.

Keywords: teachers' and students' practices at university level, novel approaches to teaching, self-efficacy beliefs, self-regulation, instructional design

INTRODUCTION

According to Lave and Wenger's (1991) view of situated learning, a set of skills as well as a set of values and perspectives are needed for a holistic understanding of a topic. Collins, Brown, and Holum (1991) suggest that the process of acquiring this kind of understanding occurs most naturally within the community possessing this knowledge. In this light, it is not irrelevant what kind of instructional practices are implemented to teach university mathematics, and how do these practices offer students opportunities to participate. As Greeno (1997, p. 9) states, "methods of instruction are not only instruments for acquiring skills; they also are practices in which students learn to participate". Therefore, to enhance students' learning, instructional designs used to teach university mathematics should offer students both an opportunity to acquire knowledge and an opportunity to become part of a community.

Partly to answer to this need, lots of effort has been put into developing the educational setting at the Department of Mathematics and Statistics at the University of Helsinki (see eg. Oikkonen, 2009; Rämö, Oinonen, & Vikberg, 2015). The department's teaching has gone through major changes during the past few years as many of the undergraduate level courses are now using the Extreme Apprenticeship (XA) method as their pedagogical framework. In addition, some of the courses working within the traditional lecture-based framework have been developed towards a more interactive direction.

This paper approaches the development of university mathematics education from the perspective of efficacy beliefs and self-regulation of learning. As a part of a larger research project aiming at comparing university mathematics teaching practices and transferring knowledge from research into practice, this paper elaborates on students' experiences of different instructional designs with the focus on their efficacy beliefs and self-regulation of learning.

THEORETICAL FRAMEWORK

Self-efficacy is a person's belief about how well they can perform a specific task in a specific context; these beliefs determine how people feel, think, motivate themselves and behave (Bandura, 1994). Self-efficacy beliefs play a crucial role in learning mathematics as self-efficacy enhances academic achievement (Pajares, 1996; Peters, 2013), especially in female students (Raelin et al., 2014). The gender aspect of self-efficacy is relevant as it affects female students' career choices and increases their retention in STEM fields (Pajares, 1996; Raelin et al., 2014). In terms of instructional design, Peters (2013) shows that students' self-efficacy is higher in teacher-centred than in learner-centred classroom. However, Kogan and Laursen (2014) argue that female students obtain affective gain from student-centred courses as they are more confident in their mathematical abilities in these kinds of contexts.

The notion of self-regulation characterises how students regulate their cognition, behaviour, motivation and emotions to enhance their personal learning processes (Pintrich, 2004). Students are expected to learn self-regulation skills during their university studies and therefore instructional designs should support the development of these skills (Coertjens et al., 2013). The self-regulation process is cyclical in nature as feedback from prior performance is used to adjust future learning performances (Pintrich, 2004; Zimmerman, 2000). Consequently, the quality of self-regulated learning is supported by motivational beliefs, such as self-efficacy beliefs (Heikkilä, & Lonka, 2006; Pajares, 1996). As the social aspect of learning has a significant role in learning self-regulation skills (Volet, Vauras, & Salonen, 2009), instructional designs should also encourage student collaboration.

Aims and research questions

The aim of the paper is to compare students' self-efficacy and self-regulation of learning in two different course contexts. The further analysis focuses on gender as previous research shows that especially female students benefit from more student-centred course designs. The research questions are:

1. How do self-efficacy and self-regulation of learning differ between the two course settings?

2. How is the course setting related to male and female students' self-efficacy and self-regulation of learning?

METHODOLOGY

This study approaches the research questions with a quantitative analysis of students' self-efficacy and self-regulation of learning in two course contexts. The following subsections move on to describe the context, the data collection procedure and data analysis in greater detail.

Context

The research was conducted in a research-intensive university in Finland. Data was collected from two different courses that students usually take during the first semester of their university mathematics studies. Both courses are proof-based, six-week and five-credit (ECTS) courses with over 200 students. In addition to mathematics majors, the courses are taken by many students studying mathematics as their minor subject; these students are usually majoring in physics, computer science, chemistry or education. The two courses, course A and course XA, are implemented in accordance with different pedagogical frameworks. The main difference in the course implementations are the role of lectures, design of the tasks, and the form of support given to the students by the teaching assistants.

Course A is an analysis course. The main content of the course includes limit of a function, continuity, derivative, and its applications. It is necessary to point out that the course is an analysis course rather than a calculus course as exact definitions and proof construction are emphasised. The course functions within the traditional lecture-based setting. However, it has been developed over a decade towards a more interactive direction to respond to students' challenges in the beginning of their university mathematics studies.

The course A consists of four hours of lectures and four hours of small group sessions per week. The lectures are focusing on the main content of the course and aim at creating deep understanding behind those concepts. Inspired by Tall's *three worlds of mathematics* (see e.g. Tall, 2014), the lectures are an active interplay between the human and formal sides of mathematics. The small group sessions are led by a teaching assistant, who is usually an older mathematics student. There are two different kinds of small group sessions. The other one is allocated to the problems students have solved prior to the class. The other small group session is allocated to solving a new set of problems during the session together with other students and with the help of the teaching assistant.

Course XA is a linear algebra and matrices course. The main content of the course includes general vector spaces, subspaces, linear mappings, and scalar products. In addition to mathematical content, the course emphasises skills such as reading mathematical text, oral and written communication, and proof construction. The course is taught with the XA method. The XA method is a student-centred educational method developed in the Department of Mathematics and Statistics and the Department of Computer Science at the University of Helsinki. The method emphasises learning by doing, personalised scaffolding and continuous feedback, and the core idea is to support students in becoming experts in their field by having them participate in activities that resemble those carried out by professionals (see eg. Rämö et al., 2015). The XA method is constructed upon the ancient process of apprenticeship, where a skilled master supervises a novice apprentice, and its theoretical background is in situated view on learning and Cognitive Apprenticeship (Collins et al., 1991; Rämö et al., 2015).

In the XA method, students learn skills and gain knowledge by working on tasks that have been divided into smaller and approachable goals, which are then merged together as the students start to master a topic. The main method of teaching is instructional scaffolding, and it is accompanied with continuous, bi-directional feedback. Further, it supports students to establish relations within the communities of practice which enhances the students' integration into the community (Lave & Wenger, 1991).

In practice, the teaching of the course consists of weekly problems, course material, guidance and three hours of lectures per week. There is a flipped learning approach as students start studying a new topic by solving a set of problems. These topics have not yet been discussed during the lectures, so students need to read the course material to complete the tasks. However, the tasks are designed to be approachable and there are teaching assistants specifically to this course helping the students in solving the problems. The teaching assistants guide the students in a learning space in the middle of the department in drop-in basis approximately six hours a day. Student collaboration is encouraged in the learning space. Students return written solutions to the problems every week. Few problems are selected for inspection and students get feedback for their solutions. The feedback focuses on solutions' logical structure, but also readability and language are evaluated, and students' have the possibility to improve and resubmit their solutions. Students are prepared when they come to lectures as they have done pre-lecture tasks. Lectures focus on active interaction as various small group activities are implemented and students' active participation encouraged. The aim is to form links between the topics and enhance holistic understanding. After the lectures students get more challenging problems on the topic.

Data collection

Quantitative data was collected on a five-point Likert scale (1=completely disagree, 5=completely agree) from students attending both courses. The questionnaire included items measuring students' approaches to learning, their experiences of the teaching-learning environment, self-efficacy and self-regulation of learning. In this paper, the analysis includes items measuring self-efficacy and self-regulation of learning from students who answered the questionnaire for both course contexts (N=91).

There are five items measuring self-efficacy. The items are slightly modified from Pintrich (1991) and they are validated and highly used across disciplines in the Finnish context (see e.g. Parpala & Lindblom-Ylänne, 2012). The 15 items measuring self-regulation of learning are originally from the Inventory of Learning Styles (ILS, Vermunt, 1994) and they have been modified to Finnish context (Heikkilä, & Lonka, 2006). There self-regulation of learning is measured in four scales: self-regulation of process, self-regulation of content, external regulation, and lack of regulation. Self-regulation of process refers to a student’s ability to regulate their own learning when facing challenges. Self-regulation of content measures student’s seeking of additional literature beyond the course material. External regulation measures to what extent the lecturer regulates student’s learning. Lack of regulation refers to possible problems in regulation of learning, such as not knowing how to proceed in the learning process or having challenges in finding ways to cover the course content.

Data analysis

The data analysis is conducted by using IBM Statistics 24. The data in this paper is a part of a larger data set. The results reported here are from the factor analyses computed for the larger data set.

At first, exploratory factor analysis (EFA) was conducted with principal axis factoring and a direct oblimin rotation. Based on the exploratory factor analysis, there are four factors measuring self-regulation of learning. This is in accordance with previous research (see eg. Heikkilä, & Lonka, 2006). Similarly, the factor structure of the self-efficacy scale is like in previous studies (see e.g. Parpala, & Lindblom-Ylänne, 2012) forming one factor. Boundaries used for Kaiser-Meyer-Olkin measure of sampling adequacy (KMO) was 0.7, and for Bartlett's test of sphericity $p<0.001$. One item measuring self-regulation of content was excluded from the factor based on a low communality, a mixed factor loading and deviant skewness and kurtosis. Every factor was then checked for internal consistency: the Cronbach’s Alpha is 0.905 for the self-efficacy factor, 0.681 for the self-regulation of process factor, 0.671 for the self-regulation of content factor, 0.708 for the external regulation factor, and 0.661 for the lack of regulation factor. The reliabilities are above the 0.65 level which can be considered acceptable.

As the current study follows a repeated measures design, the data was analysed by using two-tailed paired samples t-test and Cohen’s effect size d. In addition, one-way MANOVA with Wilk’s Lambda was used to analyse the interaction of independent variables (gender) on the dependent variables (different course settings).

RESULTS

The data consists of 91 students (46 male, 45 female). These students attended both course A and course XA. Students' scores on self-efficacy and self-regulation scales in both course contexts are presented in Table 1 with means, standard deviations, mean differences, paired-samples t-test for statistical significance, and Cohen's d for effect size.

The biggest differences between the two course contexts lie in the self-efficacy and lack of regulation factors. Students report statistically significantly higher self-efficacy levels in course XA compared to course A (MD=0.58, t(90)=6.226, p<0.001). This means that students are more confident in their abilities to succeed in course XA compared to course A. The effect size (Cohen's d=0.62) implies a moderate role for the course context when measuring self-efficacy. A similar phenomenon occurs in the lack of regulation factor; students report statistically significantly less lack of regulation in course XA compared to course A (MD=0.48, t(90)=6.987, p<0.001). In practice this means that on average, students report that they lack regulation of learning more often in course A compared to course XA. In other words, it was easier for students to find ways to handle large quantities of content, self-evaluate their learning, and to meet the learning goals in course XA compared to course A. The effect size (Cohen's d=0.63) implies a moderate role for the course context when measuring lack of regulation.

There are also smaller mean differences in the self-regulation of process and self-regulation of content factors between the two course contexts (MD=0.14 and MD=-0.19 respectively). These differences are statistically significant on a 0.05 level (t(90)=2.189, p<0.05 and t(90)=-2.383, p<0.05 respectively). The results indicate that on average, students in course XA seek more actively additional literature beyond the course material and do more work than expected when compared to course A (self-regulation of content). In addition, an average student in course XA reports that they are more capable of regulating their learning processes when facing challenges when compared to course A. However, one must notice that the effect sizes are below 0.2 suggesting an insignificant role of the course contexts.

There is no statistically significant difference in the external regulation factor (MD= 0.06, t(90)=0.941, p=0.35). This means that on average, students report that the lecturers' instruction on how and in what order to proceed in learning the content influences their learning similarly in both course contexts.

	Course A		Course XA			
Variable	Mean	SD	Mean	SD	Mean difference (XA-A)	Effect size
Self-efficacy	3.09	0.96	3.67	0.86	0.58***	0.62
Self-regulation of	2.83	0.82	2.97	0.80	0.14*	0.17

process						
Self-regulation of content	2.37	1.08	2.19	1.07	-0.19*	0.17
External regulation	3.59	0.78	3.65	0.72	0.06	0.08
Lack of regulation	3.28	0.78	2.80	0.75	-0.48***	0.63

Table 1: Students' scores, mean differences and effect sizes on the self-efficacy and self-regulation factors in courses A and XA, as determined by two-tailed paired samples t-test (* for p<0.05 and * for p<0.001 significance levels) and Cohen's d.**

Let's now move on to analyse both male and female students in one course context at a time. In course A context, male and female students differ statistically significantly in the self-efficacy factor (MD=-0.54, p<0.01, F(1,89)=6.602, partial η^2=0.079). This difference is not present in course XA context (MD=0.04, p=0.821, F(1,89)=0.038, partial η^2=0.001). These results indicate that female students have statistically significantly lower self-efficacy in course A compared to male students; however, this difference between genders is not present in course XA context.

There are statistically significant differences also in the external regulation factor. In course A context, the mean difference between male and female students is not statistically significant (MD=0.31, p=0.054, F(1,89)=3.827, partial η^2=0.041). However, the p-value is very close to the 0.05-significance level. In course XA context, male and female students differ statistically significantly in the external regulation factor (MD=0.51, p<0.001, F(1,89)=12.947, partial η^2=0.127). This means that, in course XA contexts, an average female student applies more external regulation compared to an average male student. In other words, female students report that the lecturers' instructions influence their learning more when compared to male students.

There are no statistically significant differences between male and female students in the two course contexts in self-regulation of process, self-regulation of content, and lack of regulation factors.

		Male		Female		
Factor	Course	Mean	SD	Mean	SD	Mean difference
Self-efficacy	A	3.36	0.96	2.82	0.89	-0.54**
	XA	3.65	0.96	3.69	0.72	0.04
External regulation	A	3.43	0.80	3.74	0.74	0.31(*)
	XA	3.40	0.72	3.91	0.61	0.51***

Table 2: Differences between courses A and XA based on students' gender, as determined by one-way MANOVA (* for p<0.05, ** for p<0.01, and * for p<0.001 significance levels).**

DISCUSSION

There are statistically significant differences between course A and course XA in relation to the self-efficacy and self-regulation scales. The biggest differences are in the self-efficacy and lack of regulation factors. The results show that an average student has higher self-efficacy levels in course XA than in course A, and that an average student lacks regulatory skills more often in course A than in course XA. This is supported by the effect sizes implying a moderate role for the course contexts when measuring self-efficacy and lack of regulation. The results bear significance as self-efficacy has a strong positive and lack of regulation a strong negative relation to academic performance (Pajares, 1996; Peters, 2013; Vermunt, 2005).

Gender has a statistically significant interaction with the factor measuring self-efficacy. On average, female students report lower self-efficacy levels in course A compared to male students. In contrast, the self-efficacy levels are very similar for male and female students in course XA. In practice, an average female student is less confident in her abilities to succeed in the course A context when compared to an average male student. However, it seems that the change in course context diminishes the difference as there is no statistically significant difference present between genders in the self-efficacy factor in course XA context.

Female students report more external regulation compared to male students in both course contexts. The results are statistically significant only in course XA context, but the p-value is very close to the 0.05-significance level also in course A context. This means that the lecturers instructions have more influence on female students' learning processes than on male students' learning processes. This is supported by prior research (Vermunt, 2005), although the current study does give any explanations to this phenomenon. However, in Vermunt's (2005) study there was no consistent interaction between students' gender and their learning patterns, and external regulation did not relate negatively to academic achievement. Further research is needed to understand the motivations behind this phenomenon, as well as its implications to instructional practices.

One of the major limitations of this study is that the two courses differ in content. The limitation is caused by the choice of research design as it was not possible to attain the same cohort of students in two different pedagogical settings with the same course content. However, the different course contents do not fully provide an explanation for the result that male and female students' ability to regulate and reflect on their learning processes is dependent on the course context. One can argue that the gender differences are not caused by the characteristics of the mathematics studied but by the characteristics of the learning environment used to study the mathematics. The results of this study may also be affected by the fact that some students are more capable to adopt themselves into new instructional designs. As argued by Kogan and Laursen (2014), student-centred course settings often feature collaborative work, problem-solving and communication, aspects known to be effective for female students. Also, Vermunt (2005) states that female students like cooperative learning more compared to male students. In addition, students who have high confidence in collaboration seek more likely help from other students; these help-seeking students then perform better in a flipped mathematics classroom compared to students seeking less help (Sun, Xie, & Anderman, 2018).

Despite of the limitations, the findings of this study are supported by prior research. To conclude, the results propose that student-centred course designs support students' self-efficacy and self-regulation, especially in female students. More thorough analysis should be completed to understand the mechanisms and motivations behind the differences in these two course contexts and to draw more general conclusions regarding instructional designs used in teaching university mathematics.

REFERENCES

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71-81). New York: Academic Press.

Coertjens, L., Donche, V., De Maeyer, S., Vanthournout, G., & Van Petegem, P. (2013). Modeling change in learning stratgies throughout higher education: A multi-indicator latent growth perspective. *PloS One, 8(7)*.

Collins, A., Brown, J., & Holum, A. (1991). Cognitive apprenticeship: Making thinking visible. *American Educator, 15(3),* 6-46.

Greeno, J. G. (1997). On Claims that Answer the Wrong Questions. *Educational Researcher, 26(1),* 5-17.

Heikkilä, A., & Lonka, K. (2006). Studying in higher education: students' approaches to learning, self-regulation, and cognitive strategies. *Studies in Higher Education, 31(1)*, 99-117.

Kogan, M, & Laursen S. L. (2014). Assessing long-term effects if inquiry-based learning: a case study from college mathematics. *Innovative Higher Education, 39(3)*, 183-199.

Lave, J. & Wenger, E. (1991). *Situated learning: Legitimate peripheral participation*. Cambridge: Cambridge University Press.

Oikkonen, J. (2009). Ideas and results in teaching beginning maths students. *International Journal of Mathematical Education in Science and Technology, 40(1)*, 127-138.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66(4)*, 543-578.

Parpala, A., & Lindblom-Ylämnne, S. (2012). Using a research instrument for developing quality at the university. *Quality in Higher Education, 18 (3)*, 313-328.

Peters, M. L. (2013). Examining the relationships among classroom climate, self-efficacy, and achievement in undergraduate mathematics: a multilevel analysis. *International Journal of Science and Mathematics Education, 11(2)*, 459-480.

Pintrich, P. R. (1991). A manual for the use of the Motivated Strategies for Learning Questionnaire (MSLQ).

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review, 16(4)*, 385–407.

Raelin, J. A., Bailey, M. B., Hamann, J., Pendleton, L. K., Reisberg, R., & Whitman, D. L. (2014). The gendered effect of cooperative education, contextual support, and self-efficacy on undergraduate retention. *Journal of Engineering Education, 103*, 599–624.

Rämö, J., Oinonen, L., & Vikberg, T. (2015). Extreme Apprenticeship – Emphasising Conceptual Understanding in Undergraduate Mathematics. In K. Krainer, & N. Vondrová (Eds.), *Proceedings of the Ninth Congress of the European Society for Research in Mathematics Education (CERME9, 4-8 February 2015) (pp. 2242–2248)*. Prague, Czech Republic: Charles University in Prague, Faculty of Education and ERME.

Sun, Z., Xie, K., & Anderman, L. H. (2018). The role of self-regulated learning in students' success in flipped undergraduate math courses. *The Internet and Higher Education, 36*, 41-53.

Tall, D. (2014). *How humans learn to think mathematically: exploring the three worlds of mathematics*. Cambridge: Cambridge University Press.

Vermunt, J. D. (2005). Relations between student learning patterns and personal and contextual factors and academic performance. *Higher Education, 49*, 205-234.

Vermunt, J. D. (1994). Inventory of Learning Styles in higher education: Scoring key. Tilburg University, Department of Educational Psychology.

Volet, S., Vauras, M., & Salonen, P. (2009). Self- and social regulation in learning contexts: An integrative perspective. *Educational Psychologist, 44(4)*, 215–226.

Zimmerman, B. J. (2000). Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 13–39). San Diego, CA: Academic Press.