The Effects of Inquiry-Based Learning in Higher Education Statistics Tutorials on Students' Self-Efficacy, Attitudes, and Achievement Emotions

Petra Bod, LMU München, petra.bod@campus.lmu.de
Daniel Sommerhoff, LMU München, sommerhoff@math.lmu.de

Abstract: This pilot investigation explored the effects of an inquiry-based learning environment on students' self-efficacy, attitudes, and achievement emotions in the context of higher education statistics tutorials. Results showed positive effects of the learning environment, leading to increased self-efficacy, and more positive attitudes and achievement emotions. First evidence on the intercorrelations among the three variables point towards positive, pairwise relationships. The findings emphasise the need for future research and a larger scale investigation on the topic.

Introduction

Statistics is an increasingly important and relevant subject in the age of big data. The ability to analyse and interpret data is becoming essential in many professional tracks. Despite the subject's importance, large proportions of students in higher education do not like statistics classes, and up to 80% of these students show signs of statistics anxiety (Onwuegbuzie & Wilson, 2003). To effectively reduce this high figure, research needs to investigate the mechanisms underlying students' negative reactions towards statistics, and try to improve the current situation, for example via changes in the instructional design of statistics classes.

Here, the instructional design inquiry-based learning (IBL) appears promising, as it was found to increase students' confidence in and attitude towards mathematics in higher education (Laursen, Hassi, Kogan, Hunter & Weston, 2011). Based on these findings in mathematics, our project aimed to explore the effects of IBL in the context of statistics, which is the most relevant aspect of mathematics in most social sciences. For this, we designed an inquiry-based learning environment within a postgraduate-level statistics tutorial and measured its effects on students' self-efficacy to learn statistics, as well as their attitudes and achievement emotions towards the subject.

Background

Prior research on the emotions of university students showed that statistics anxiety is negatively correlated with students' self-efficacy to learn the subject (Perepiczka, Chandler & Becerra, 2011), which provided grounds for our project to further examine self-efficacy in the context of higher education statistics. However, several other variables have been indicated to influence students' overall view of a subject, such as attitudes and achievement emotions (Di Martino & Zan, 2011; Pekrun, 2006). Although IBL was shown to have a positive effect on the variables individually, these three aspects have not been investigated together in this context up to now.

The observed positive effects can be related to the fact that IBL encourages students to overcome obstacles on their own, providing grounds for encountering authentic success, which was emphasised as the most effective way to induce self-efficacy in academic settings (Bandura, 2009). The positive effects as well as the connectedness of the three variables can further be explained by the control-value theory (Pekrun, 2006), which highlights the influence of students' perceptions of their control over a given task, as well as the subjective value of that task.

Research Questions

1. Does IBL lead to an increase in students' self-efficacy to learn statistics, positive attitudes, and positive achievement emotions towards statistics?

   For this question, positive results were expected based on similar findings in higher education mathematics, and the similarity between both subjects.

2. Are self-efficacy, attitudes, and achievement emotions positively correlated in the context of statistics?

Method

The intervention spanned over five subsequent tutorials for a Master's level statistics class. Each session consisted of the distribution of a real-life scenario to help students understand the practical applications of statistical

methods. Based on the scenario and other related documents, students would embark on individual journeys of inquiry, and complete a series of steps: formation of research questions, data analysis, interpretation of results, and presentation of research findings. The tasks were created to match the stages of the inquiry cycle (Murdoch, 2006).

Testing was carried out at three timepoints: during the first (N = 20), the third (N = 14), and the fifth session (N = 8). The first and last measurements assessed all three variables, providing a pre-post comparison, whereas the second measurement only assessed students' achievement emotions. We measured students' responses on three Likert-type scales from existing literature, which were adapted to the context. The scales measured the three variables of interest, namely self-efficacy (Finney & Schraw, 2003), attitudes (Schau & Emmioglu, 2012), and achievement emotions (Pekrun, Goetz & Perry, 2005). All three scales were found highly reliable ($\alpha > .92$).

Results

Compared to the start of the intervention, students showed higher levels of self-efficacy to learn statistics (d = 1.10), more positive attitudes (d = 0.94), and more positive achievement emotions (d = 1.42). Achievement emotions showed a positive trajectory from the first to the third (d = 1.04), as well as the third to the fifth session (d = 0.31). A significant correlation was only found between attitudes and achievement emotions at the pre-test ($\rho = .85$, $p < .001$). The other correlations did not reach significance, but showed partially moderate relationships: attitudes and achievement emotions (post: $\rho = .47$, $p = .243$), achievement emotions and self-efficacy (pre: $\rho = .42$, $p = .098$, post: $\rho = .17$, $p = .691$), and attitudes and self-efficacy (pre: $\rho = .21$, $p = .366$, post: $\rho = .24$, $p = .570$).

Discussion

Results underline that the use of IBL has a positive influence on students' self-efficacy to learn statistics, and on their attitudes and achievement emotions towards statistics, which is in line with prior research (Laursen et al., 2011). Our results further expand the scope of previous research by analysing the relation among the three variables, showing a strong connection between attitudes towards learning statistics and students' achievement emotions during the IBL sessions. The other correlations did not reach significance, likely due to the small sample size in this first investigation. Moreover, the lack of a control group requires cautious interpretation of the longitudinal results. The continuation of the project aims to overcome these limitations and to allow a more detailed analysis of the relationship between IBL and students' affective outcomes in higher education statistics.

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