The effects of peer review and reproducibility on learning: A randomized experiment based on the xycoon stock exchange

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This paper attempts to investigate the causal effects of Reproducible Computing (RC) technology [8] and Peer Review (PR) activities on students' abilities to learn new concepts and apply them within a game-based decision-making environment. The game is based on the *Xycoon Stock Exchange* (XSE), which is a virtual e-learning environment where students can engage in real trading activities and learn about the economic principles of the stock market and its underlying statistical properties. Unlike other trading games, the XSE engine is based on technology that was originally developed for creating fully functional, web-based stock exchanges and has been used by Euronext [2] and the European Commission [3] for educational and training purposes. All price fluctuations are the result of bid and ask orders that are processed in real-time. The orders are created by the participating students, the educator, and an optional computer trader which is enhanced by Artificial Intelligence, which relies on heuristic rules from past research of actual trading activities and their relationship with external factors like news messages and various types of economic indicators [1].

The population of XSE game participants consists of four relevant cohorts [7] each of which is subdivided into four randomized treatment groups: the "maturationist" group (having access to RC and PR but without any guidance from the educator), the "worked-example" group (with access to RC but not PR), the "constructivist" group (with access to RC, PR and educator guidance), and the control group. For instance, students from the "constructivist" group can use an R-based RC framework that empowers them to analyze the stock market time series in real-time, and experience the importance of statistical concepts such as autocorrelation, conditional heteroskedasticity, persistence, kurtosis, and various econometric techniques that are typically useful for stock market traders [6]. During the learning phase, these students use the RC features to write assignment papers and PR feedback reports, which constitutes the "constructivist" aspect of their learning.

We investigate the effects of each treatment on learning outcomes (as measured by ex-post tests) and the effect on actual trading activities, including the success of the associated investment decisions. The rationale behind this is that understanding of the underlying learning concepts is insufficient to describe the potential effects of competing learning approaches – changes in actual behavior and attitudes (such as risk aversion) may be equally (if not more) important.

We also present a brief overview of the psychological constructs (such as overconfidence; anxiety; attitudes towards thinking and learning; etc.) that were measured by several surveys, and how they relate to the experimental findings of the XSE experiment. Finally, we argue that challenging, web-based games can be helpful to build constructivist learning environments and to assess the effects of competing pedagogical approaches.

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