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Digital learning environments for mathematics education – A workshop on stochastic paradoxes

Ingrid Lenhardt¹ and Lea Schenk²

¹Karlsruhe Institute of Technology, Faculty of Education, Karlsruhe, Germany;
ingrid.lenhardt@kit.edu

²Karlsruhe Institute of Technology, Faculty of Education, Karlsruhe, Germany; lea.schenk@kit.edu

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Preconditions and motivation

Digital technologies can support and benefit mathematical learning processes, especially the development of students' statistical reasoning, but also have their limitations (Thurm, 2020, Biehler et al., 2013). In order for student teachers to reflectively use digital technologies at an early stage of their teacher training, the seminar "Digitalbasierte Lernkontexte des Mathematikunterrichts" (Eng. Digital learning environments for mathematics educations) was developed. There, student teachers develop, test, evaluate, and reflect on digital learning environments for relevant, authentic applications of mathematics in a Design-Based research approach (Bakker & Eerde, 2015). Below, we present a workshop developed by students who pursued the initial research question: How can we profitably employ digital technologies in teaching stochastic paradoxes?

Storyline

The 90-minute workshop starts with a joint introduction to the situation via radio recording. The state "Tralien" is struggling with the serious disease "Frost" as well as with substantial financial problems. A pharmaceutical company presents two drugs to cure the disease. However, due to a lack of financial resources, a decision has to be made in favour of the production of one of the drugs. Furthermore, when aid money is put up, it is discovered that "Tralien" is missing large amounts of tax money. This causes the financial problems and leads to a second task: tax evaders must be exposed. Upon this introduction, students form two expert groups who work on the problems almost independently guided by GeoGebra books and additional material in Excel and R. The first group learns about the Simpson paradox and how it relates to the choice of one of the two drugs. The second group deals with Benford's law and applies it to expose tax evaders. Finally, each group presents the findings.

Didactic considerations and digital tools

A statement is judged as paradoxical, if it conflicts with another self-evident statement. Hence, a reason for working with stochastic paradoxes is that students conflict with their intuition and have to correct misconceptions. In doing so, existing conceptions must be recognized as incorrect, underlying errors must be understood and then a correct conception can be formed. This process of understanding errors and building new conceptions is common in many learning areas (Winter, 1992). Simpson's paradox (Meyer, 2018) and Benford's law (Humenberger, 2018) offer many starting points here. Another reason to choose stochastic paradoxes is their relation to students' everyday life. Students are exposed to statistics of large data sets and their interpretation. Thus, they should internalize the relevance of proper handling of statistical results as well as how to evaluate and interpret data sets.

To further emphasize the relevance of the content, the workshop is based on real, publicly available data and students are introduced to software used in data analysis (R, Excel). These tools allow the demonstration of the processing of large amounts of data as well as its visualization, while reducing schematic operations. Currently, however, students do not program themselves. Instead, the focus is on the discussion and interpretation of the finished code and relevant diagrams. In further revisions, we plan to enable students to complete programming tasks too, using Jupyter Notebooks. For now, GeoGebra books guide through the workshop. The many different tools in GeoGebra enable a diverse design and a clear structure of learning tasks, as well as visualisation and change of representation to promote comprehension. GeoGebra serves as an information and presentation tool, so students can work on the materials almost independently and are not bound by space or time. In addition, GeoGebra Classroom provides a virtual classroom, where teachers can view students' answers and identify potential problems and misunderstanding, allowing for individualized learning guidance.

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