STEAM-based learning ecosystems involving Digital Toolkits, Tutoring Systems, 3D Printing and Mathematical Trails

Ben Haas[1], Yves Kreis[2], Zsolt Lavicza[1], Tony Houghton[1] and Kristof Fenyvesi[3]

Johannes Kepler University Linz[1], Austria, University of Luxemburg[2], Luxembourg, University of Jyväskylä[3], Finland, ben.haas@outlook.com

Keywords: STEM Education, Teacher education programs, Educational technology.

During the past 5 years, we have been experimenting with a wide range of educational technologies in elementary schools and higher education with a focus on STEAM (Science-Technology-Engineering-Arts-Mathematics) integration and exploring role of mathematics within STEAM. These projects included STEAM integrated approaches for teacher training, special needs education with Augmented Reality and 3D Printing, remote teaching and automated tutoring systems. Over this period we observed a shift towards technology-based teaching and learning in education, and we aimed to identify how educational ecosystems with a variety of technologies such as Augmented Reality, 3D Printing, or tutoring systems could provide increased accessibility and opportunities for STEAM-based educational approaches. In this poster, we will give an overview of how the above-mentioned technologies could be employed by different users for teaching and learning STEAM-based educational ecosystem. Thus, in our research, we evaluated effects on students' learning in our educational projects. These projects involved automated tutoring systems, mathematical modelling of real-world objects with CAD Software, Dynamic Mathematics Software and 3D Printing devices, and outdoor mathematical trails with GPS-supported software and a number of Erasmus+ projects contributed to our studies Each study originate from the projects mentioned above was embedded within a joint research framework, nurtured by the results and participants' feedback from our studies. Building on this framework we focused on identifying how students, teachers, pre-service teachers and parents could access learning tasks and settings with different educational technologies and experience new opportunities in STEAM learning. From complementary findings of these studies we identified the importance of an interconnection of the different tasks and technologies, which can contribute to a creative, learning ecology (Szabó et al., 2021) of mathematics learning. Each kind of technology supports different approaches to learning and teaching, and in the combination of various technologies offers a wider accessibility to skills and knowledge for both teachers and students. Hence, in this poster, we present how the different educational technologies utilizing our findings could be used in an educational ecosystem, supporting with technology-based creative approaches.

Methods

Tasks and uses of technologies were based on the interplay of Blums and Leiß modelling theory (Blum & Leiß, 2007), problem-solving approaches (Liljedahl et al., 2016), Dienes' principles on learning (Dienes, 1960) and STEAM pedagogical frameworks (Haas, 2021). The tasks we elaborated in these projects are linked to school curricula and based on reliable methodologies implemented in schools and higher education training (e.g.: active discoveries, peer learning, student-centered learning). We followed recent studies on creative ecologies of everyday learning to identify structures for a system implementation (e.g.: Szabó et al., 2021). In every study, we followed a design-based

research methodology (Lee & Hannafin, 2016). However, we adapted the methodology slightly for the different studies, due to the used technologies, environment, or possibilities and the restrictions imposed by the COVID-19 pandemic. Moreover, we used quantitative, qualitative and mixed-methods triangulation in the different studies. We will present methods separately for each study in the poster. We obtained results indicating that those educational technologies with real-world connections are likely to engage students, parents and teachers in new motivating and creative ways.

Discussion

Through addressing open-ended problems using guided support with decreasing feedback and scaffolding, our learners and teachers were able to develop their process skills and content skills in STEAM disciplines at their own pace. These task designs can be implemented in creating new learning settings and each technology supports students in their learning and teachers or parents in their teachings. Students could use the automated tutoring system in class or at home to train process skills with scaffoldings and learn to apply these skills in active mathematical modelling approaches with real-world information, situations, objects, or places. Thus, over time it could be a valuable asset to support students individually or in groups or even the entire class with the automated tutoring system within traditional courses. With the dynamic geometry software, CAD software and 3D printing, students learned new strategies and skills. The solving behaviour in geometric tasks gained in structure and the visual-spatial ability was developed (Haas, 2021). Further, students gained confidence and experience through a play-based approach to tasks with enjoyment. Finally, with GPS-supported software, we were able to transfer learning directly into students' real world in combination with Augmented Reality, 3D printing, and Dynamic Geometry Software.

References

Blum, W., & Leiß, D. (2007). How do students and teachers deal with modelling problems? In C. Haines, P. Galbraith, W. Blum, & S. Khan (Eds.), *Mathematical modelling (ICTMA 12): Education, engineering and economics* (pp. 222–231). Woodhead Publishing.

Dienes, Z. P. (1960). *Building up mathematics*. Hutchinson Educational.

Haas, B. (2021). Transition from in-class to outdoor learning with real-world mathematical modelling [Doctoral dissertation, Johannes Kepler University Linz].

Lee, E., & Hannafin, M. J. (2016). A design framework for enhancing engagement in student-centered learning: Own it, learn it, and share it. *Educational Technology Research and Development*, *64*(4), 707–734. https://doi.org/10.1007/s11423-015-9422-5

Liljedahl, P., Santos-Trigo, M., Malaspina, U., & Bruder, R. (2016). Problem solving in mathematics education. Springer. https://doi.org/10.1007/978-3-319-40730-2

Szabó, T. P., Burnard, P., Harris, A., Fenyvesi, K., Soundararaj, G., & Kangasvieri, T. (2021). Multiple creativities put to work for creative ecologies in teacher professional learning: A vision and practice of everyday creativity. In S. Lemmetty, K. Collin, V. P. Glăveanu, & P. Forsman (Eds.), *Creativity and learning: Contexts, processes and support* (pp. 115–143). Springer. https://doi.org/10.1007/978-3-030-77066-2_6