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Serious Games for Mathematics Support in Higher Education

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Abstract. Serious games may complement existing content in higher education and promote student engagement with taught materials. A systemic review of serious games for mathematics support in higher education between 2008 and 2018 was undertaken. There was limited research in this specific area but key themes emerged. These were the application of ARCS theory for initial design, technical considerations in creating serious games for mathematics, consideration of student computing abilities and provision of clear instruction and training prior to use. The review will inform the development of a local gaming resource to support existing mathematics support materials.

Keywords: Mathematics, Numeracy, Serious Games, Support

1 Introduction

Wide ranges of resources are available to support undergraduate students with the mathematics requirements of science, technology, engineering and mathematics courses. Institutions may have a dedicated mathematics support centre as part of their academic support, embed the mathematics support into the course content or use an extensive array of text, quiz and video resources such as those available from mathcentre [1]. University of Westminster, School of Life Sciences, mathematics support currently comprises of a series of brief instructional videos, worksheets, automated quizzes on the virtual learning environment and a locally produced booklet supporting the content. Small group face-to-face drop in tutorials are available throughout the year and are popular with those attending. A bespoke interactive resource was also created in 2011 but has had limited usefulness due to its perceived complexity by students [2]. In order to determine the extent of serious games incorporation into higher education mathematics support, a systematic review of publications from 2008 to 2018 was undertaken.

2 Method

Using University of Westminster Library Search, ERIC, Google Scholar and Science Direct, a search was performed on the terms *mathematics* and *serious games* in the title and/or abstract. From the fifty-four articles sourced, nine were duplicates and thirty-seven excluded as the focus was on primary and secondary school education or there was no specific mathematics information. The content of the remaining eight articles summarised for the review.

3 Results

The small number of articles demonstrated that currently there is limited use of serious games for mathematics support in higher education. Some key themes emerged however, for application to the design and production of such resources. Pedagogic theories such as ARCS [3] are applicable from the early stages of serious game design [4] [5]. Toolkits and guidance are available for the production of mathematics serious games suitable for higher education purposes. One suitable for advanced mathematics incorporates the use of Python's C API, Python's SymPy and MatPlotLib libraries and C# DLL [6]. Single or multiplayer games should be considered to suit learner preferences, for some students group interactions for problem solving may be beneficial in the same way as preference for forming study groups. The computer skills and experience of intended users must be carefully assessed and suitable initial guidance and instruction on the use of games be provided [7]. Presently there is no consideration of serious games for summative assessment for mathematics but they represent a means of formative assessment. No articles included pilot studies for the incorporation of serious games into existing higher education mathematics support resources.

4 Conclusion

To maximize the usefulness of serious games for mathematics support the design can be undertaken in partnership with students of variable mathematics entry qualifications and self-assessed computing skills. The resource should be compatible with the local virtual learning environment and enable users to view feedback on their progress and see correct answers on completion of each game. Games should be available at different levels of difficulty with each level acting as a standalone resource to avoid negative experiences for users. Written and video guides to the purpose and use of the serious games are required in addition to initial face-to-face tuition. In addition, a local programming toolkit will enable undergraduate and postgraduate computer science students to develop and expand the resources. Combining existing mathematics support resources with serious games may align well to the learning preferences of some students and enhance their development of these skills.

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