Of Marbles and Minecraft: Designing STEM Educational Games for Culturally Diverse Young Learners in Malaysia

Kee-Man Chuah
Faculty of Language and
Communication
Universiti Malaysia Sarawak
Kotra Samarahan, Malaysia
kmchuah@unimas.my

Fitri Suraya Mohamad
Faculty of Cognitive Sciences and
Human Development
Universiti Malaysia Sarawak
Kotra Samarahan, Malaysia
mfitri@unimas.my

Jacey-Lynn Minoi
Faculty of Computer Sciences and
Information Technology
Universiti Malaysia Sarawak
Kotra Samarahan, Malaysia
jacey@unimas.my

Muhammad Kamarul Kabilan
School of Educational Studies
Universiti Sains Malaysia
Pulau Pinang, Malaysia
kabilan@usm.my

Abstract—**Gamification has been widely touted as a useful approach in motivating learners to learn subjects that are perceived as challenging, such as science, technology, engineering, and mathematics (STEM). This paper reports the process of considering various cultural and social factors in the design of educational games using game design thinking approach. Educational games for STEM subjects were designed and developed through an iteration process that considered the contextual significance of learners' diverse cultural backgrounds. Online and traditional games were used as sources of inspiration, and they were re-designed to fit with learner's interests and context. The findings from 42 learners who played the role as the game designers showed significant impact of the empathy stage in the design loop where cultural elements were shared and integrated into the design. The participatory design approach proves to be very useful in encouraging learners to provide their ideas. Some learners who had limited exposure to computer or video games were still able to combine suitable game mechanics and draw ideas from their surroundings to create their own games. The findings also reveal differing viewpoints of urban and rural learners with regards to use of games of learning. The outcomes from this study provided valuable insights in the formulation of a framework for game design that takes into account learners' diversity.**

Keywords—gamification, learner diversity, empathy, game design thinking

I. INTRODUCTION

The teaching of science, technology, engineering, and mathematics (STEM) subjects in school has always been a challenge due to the perceived difficulty by the learners. These subjects are often regarded as challenging as they contain content, which may not be relatable to students the way they are taught in schools [1]. Students also need to be constantly motivated in learning STEM subjects so that their interest can be sustained [2]. To address these issues, efforts to include playful learning in these subjects were evident especially in the last two decades. Many educational games related to STEM have been introduced [3] and teachers now have access to a plethora of useful tools to design and develop their own games [4]. Empirical evidence on the use of games in teaching and learning has also pointed to its positive impacts on learning outcomes though elements of accommodating cultural differences are still missing in most studies [4].

Furthermore, the meta-analysis on gamification in learning done by Sailer and Homner [5] revealed the lack of theoretical foundation in guiding game design with a special focus on the issues of learners' diversity or personalized learning. This apparent gap could be the reason why some games cannot be effectively used in certain learning contexts. Hence, this paper reports an exploratory study on the inclusion of learner diversity as a contributing element in the game design process. It aims to investigate whether learners would be able to be active contributors in STEM-related game design when their cultural differences are given priority in the process while exploring their perceptions on the co-design experience.

The remainder of this paper is structured as follows: Section II provides an overview of pertinent literature related to the scope of the study. Section III explains the methods in carrying out the study. This is then followed by the presentation of findings and discussion in relation to previous studies in Section IV. Finally, the paper ends with Section V that conclude the paper by highlighting the implications and limitations of the study.

II. RELATED WORK

The impacts of gamification on learning and instruction have been widely studied. In the study by Harrison et al. [6], they used game creation and play to assess computational thinking and mathematics among high school students in a three-day challenge. In teams of three, 54 students were required to complete a task related to the game creation every day. The students' created games were then evaluated to find out how well students incorporated mathematics in their games. Their findings showed that the game creation task was well-received by the learners although they were only in fourth grade (10 years old). The tasks have also allowed them to learn mathematics in a more engaging manner in which they get to test each other's games. This study has proven that game design can be implemented at a young age, but the authors did not include cultural backgrounds as one of the elements in the design process.

In a study by Sakulkueakulsuk et al. [7] in Thailand, they integrated machine learning, gamification and social context in STEM learning by allowing middle school students to learn artificial intelligence. They created games based on machine learning and used mangoes as the context since it is a popular