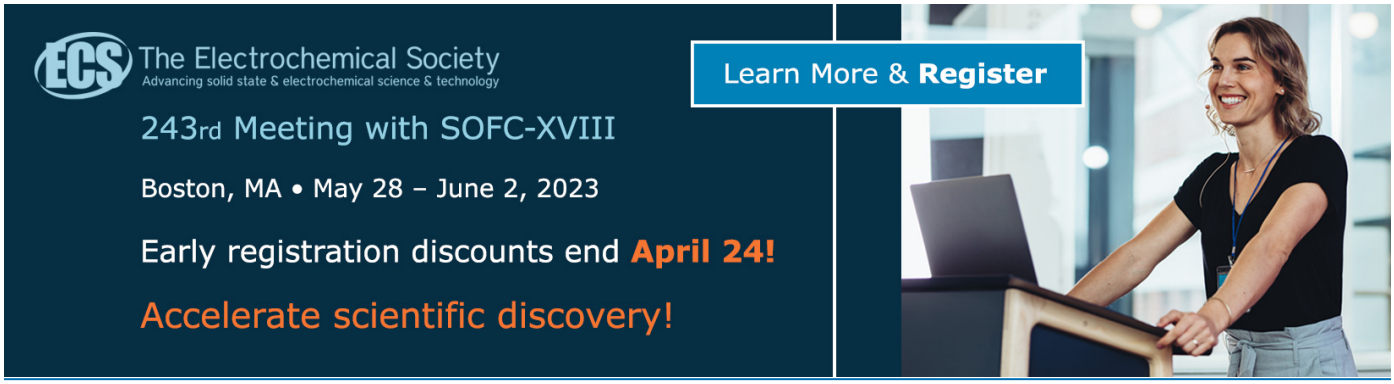
Flood preparedness module for Malaysian Higher Education students via Metaverse Environment



Flood preparedness module for Malaysian Higher Education students via Metaverse Environment

N F Sa don[1], H S Sa don[2], R A Alias [3], H Nakanishi[4]
[1]English Language Teaching Centre, Ministry of Education Malaysia
[2]Politeknik Premier Sultan Salahuddin Abdul Aziz Shah
[3]Universiti Teknologi Malaysia
[4]Saga University

E-mail: fadzleen.sadon@eltc.edu.my

Abstract. In Malaysia, the severity of natural disasters such as floods, landslides, and earthquakes have increased in recent years, making disaster preparedness a crucial aspect of students' lives. In the context of flood preparedness, accessibility to materials on flood is still in deficit and a future-ready learning approach is required. This is parallel to Sustainable Development Goals Goal 4 in promoting lifelong learning opportunities for all. The objective of this research is twofold: to study flood preparedness among Malaysian higher education students and to propose a flood preparedness module for Malaysian higher education students via Metaverse environment. The module is developed using Spatial.io, an immersive shared AR platform. For this research, the module addresses flood which is presented via a 3-D virtual learning space. This beta version will opt for multiple-stage sampling method via a focus group comprising 10 PPSSAAS students. Then, UX Testing, and post-test are conducted to gauge the module usability and latent potentials. Based on the research, the use of metaverse for the flood preparedness module shows significant impact amongst the respondents. The finding from this research is hoped to enhance students' knowledge and awareness of flood preparedness so students can care for themselves and be of help to others during an emergency.

1. Introduction

Malaysia experiences myriad natural disasters where of all the natural disasters in Malaysia, flood is considered as the most frequent and damaging hydro-meteorological hazard. Floods often occur in Malaysia due to the increase in the frequency of rainfall, sea elevation, torrential monsoonal downpour, and uncontrolled development. Flood affects the livelihood of the society, causing extensive damage to physical infrastructure, socio-economic stability as well as psychological and emotional stability. The risk of flooding is increased because of increased development, which reduces land's water storing capabilities. In Malaysia, 98.7% of annual average loss is contributed by flood [1]. the average loss from natural disasters, particularly from floods, can vary widely depending on several factors such as infrastructure, urbanization, and land use practices. Based on the Special Report on Impact of Floods in Malaysia 2021 by the Department of Statistics Malaysia, RM6.1 billion of overall losses were recorded due to the floods that hit the nation in the late 2021 and early 2022 [2]. This encompasses property and crop damage, number of casualties, disease epidemics and other intangible losses. Preparedness is part of systematic incorporation of disaster risk management. Hence, disaster preparedness is crucial in mitigating the severe impacts of flood hazard. In the Malaysian context, flood preparedness is government-centred [3] and the biggest challenge for flood management in Malaysia is its heavy reliance

on reactiveness than preparedness. Reactiveness refers to rehabilitation and reconstruction while preparedness refers to prediction and information pertaining to flood. Identifying sustainable strategy in enhancing disaster preparedness is vital where mobilising society in disaster preparedness can lessen the cost required for rehabilitation and reconstruction. Demographically, students who live in flood-prone areas are categorised as vulnerable population due to socio-economic characteristics such as age factor, lack of financial stability and experience deficit. [4] Albeit the vulnerability perspectives on students, studies have shown that higher education students have wider adroitness and accessibility to technology and possess higher mental and change agility in facing unprecedented situations such as natural hazard vulnerabilities [5,6].

The objective of this research is two-fold: to study flood preparedness among Malaysian higher education students and to propose a flood preparedness module among Malaysian higher education students via Metaverse environment. Hence, this inter-disciplinary study aims to identify how providing flood preparedness using a state-of-the-art online learning approach can enhance the higher education students' preparedness in facing the hazards of flood.

Flash floods, monsoon floods, and floods brought on by high tides are the types of floods that Malaysia is most frequently plagued by, and they all result in major and expensive damages. [7]. After the nation experienced its worst monsoon flood, which struck multiple states in December 2014 and affected 541,896 people with projected damages of RM2. 6 billion, the National Disaster Management Agency (NADMA) was established in 2015 as the nexus of disaster management agency in Malaysia. It synthesizes disaster risk management with other agencies such as MET Malaysia, the Department of Irrigation and Drainage (JPS) and the Public Works Department in weather forecasting, monitoring of river and dam water levels and liaise assets and logistics preparedness and rehabilitation. The magnitude of floods which hit the country at the end of 2021 and the beginning of 2022 have caused detrimental destruction. Figure 1 illustrates the assessment of total loss due to floods by state and Selangor experiences the highest total loss of RM3.1 billion due to floods [2]. Shah Alam is one of the cities in Selangor which experienced perennial flood that causes where over 70,000 displaced and 14 fatalities [8] .

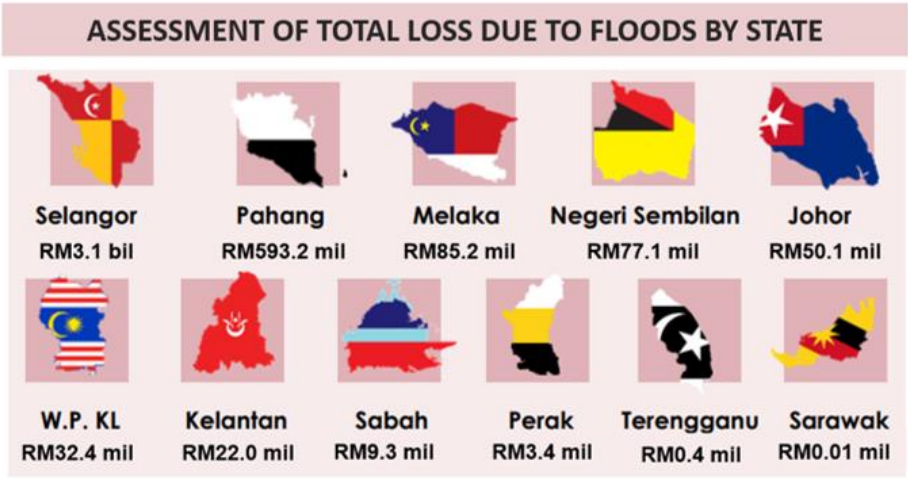


Figure 1. Assessment of total loss due to floods by state in 2021 [2]

Myriad studies have been conducted to determine factors that affect disaster preparedness initiatives. One of the main factors affecting disaster preparedness is hazard knowledge [9,10]. The more knowledge an individual has on disaster risk management will elevate the confidence level and lessen the vulnerabilities faced during pervasive flood hazard. Personal elements (attitude, risk perception, and intention to prepare) is proven to be major determinants to disaster preparedness. Identifying these factors, NADMA has organised Community Based Disaster Management programme (CBDM) which

provides workshops and forums on disaster preparedness [11]. In the context of students living to locations that are prone to flooding, possessing adequate hazard knowledge can impact individual's readiness behaviour [12]. Hence, this exalts individual's perceptions of flood risk management as it is vital for students to be alert of flood, especially if they are living in a flood-prone areas.

In the context of flood preparedness, serious games have been implemented in to increase hazard knowledge and disaster preparedness[13,14]. These days, serious games are highly considered to deploy engaging method of tackling societal issues in the realms of entertainment, psychology, computer science, engineering, and education. The term 'Metaverse' is a portmanteau that combines the words 'meta' and 'universe' and it is helmed as a new paradigm in immersive interaction by synthesizing Virtual Reality, Augmented Reality and Mixed Reality [15] Metaverse environment can be optimised for serious games for the purpose of training and educating students on flood preparedness. The dissemination of information on complex issues in serious games can heighten intrinsic awareness on the risks associated with flood [16]. Majority of serious games end-users are adults who are studying in higher educational institutions. Research conducted on the usage of metaverse in learning identified how metaverse enhances the sense of presence and immersion is recognised as a crucial element in the improvement of learning rates [17].

2. Method

Multi-stage sampling method was chosen is carrying out this research. Figure 2 illustrates the design and implementation steps of immersive virtual learning that can be carried out for learning tasks. There are 3 main phases consisting of pre-design, design and evaluation where the outcome and experience are assessed to determine the impact of the lesson.

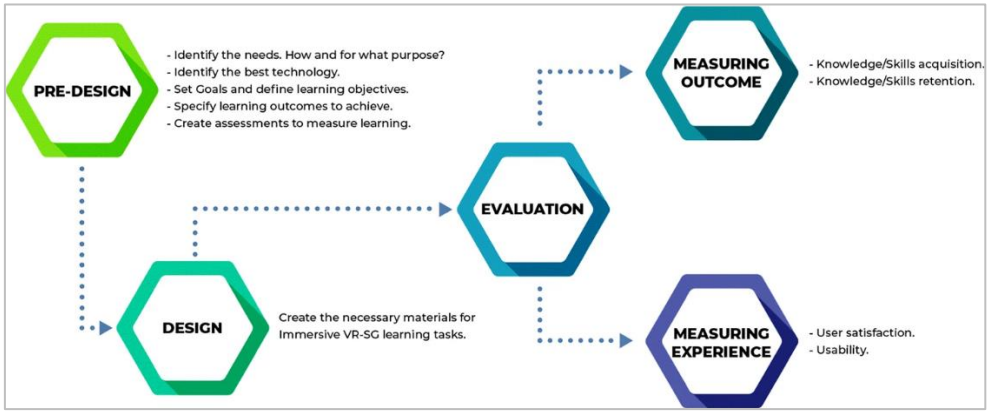


Figure 2. Flow chart for the design and implementation of immersive virtual learning for learning task

The first stage is secondary data collection where flood-prone areas in Central Peninsular Malaysia is retrieved from the Special Report on Impact of Floods in Malaysia by the Department of Statistics Malaysia and the NADMA. From the secondary data review, Selangor is the most affected state due to perennial flood and Shah Alam has been identified as one of the most flood-prone area (refer to Figure 1). This leads to the second stage in identifying the respondents who lives and study in a higher educational institution in Shah Alam. For this research, Politeknik Premier Sultan Salahuddin Abdul Aziz Shah (PPSSAAS) is chosen. Next, a focus group consisting of 10 first year students from PPSSAAS are selected to conduct the data collection. The number of respondents is ideal for homogeneous sampling. The fourth stage is when the respondents were interviewed on their living quarter location, experience with flood before being asked 3 questions : background knowledge on flood preparedness, exposure to materials on flood preparedness and their readiness in caring for themselves and other during flood.

The next stage is when the respondents access the Flood Preparedness Module via Flood Preparedness Gallery (https://tinyurl.com/floodpgallery) which was developed and hosted on Spatial.io a metaverse platform which provides virtual space for socialising, educating and networking (Refer to Figure 3). Perusing the flowchart for design and implementation in Figure 2, the activities were designed based on the intended learning objective which is to prepare a flood preparedness module in the context of Malaysia disaster management, infographics and information pertaining to crucial hazard knowledge on flood management machineries in Malaysia. The space consisted of interactive videos, AR and VR based learning activities such as an interactive quiz, escape games and real-time access to flood management websites in Malaysia such as NADMA and infoBanjir. The activities are accessible via QR Code. Figure 4 depicts the immersive escape game which was developed based on flood preparedness in Malaysia.

Figure 3. Students experiencing metaverse learning via Spatial.io

Figure 4. Screenshots of Flood Preparedness Escape Game

For the evaluation phase, it discusses the procedures and methods of evaluating the design of flood preparedness module that is carried out against the respondents. This evaluation aims to measure the level of usability of the developed application interface design and further evaluate whether the implemented design reaches the level of user needs. This evaluation is done by using the User Experience Testing (UX Testing) method through Guessability, Think Aloud and Observation method where respondents need to answer the questions asked by the researcher after using the flood preparedness module.

Additionally, the focus is on improving the engagement and interface design based on employing various viewpoints to improve the programme usability and learning capacity. UX testing is done on the application's interface design to get direct user input through user questionnaires and observation of users while they're using the applications. Based on a tool called UX Honeycomb, this tool illustrates different elements of user experience design using 7 aspects consist of Functionality, Usability, Desire, Retrievability, Accessibility, Reliability and Value [18].

The triangulation method, also known as a mixed method, which integrates different research techniques to explore a subject, is then used to evaluate the flood preparedness apps. The triangulation method has combined three techniques: guessability, think aloud, and observation. The user experience with the current interface was assessed in terms of navigation, input, colour, menu layout/instructions/icon, and text display (size, colour and text type) using the guessability's evaluation technique [19]. The think aloud technique, in contrast, uses verbal thinking as data. Participants are asked to speak while completing the tasks given, and each of these processes was observed and recorded. For this application's user experience testing, an observation session seeks to gather data by closely examining how users interact with the product. This is done to assess the quantitative metrics including the application's effectiveness, efficiency, and general satisfaction (ISO 9241-11). Users are compelled to respond to a survey about additional subjective factors with application, like ease of use and level of happiness.

The following phases are included in a user experience testing session that uses triangulation techniques such as guessability, think aloud, and observation:

1. A facilitator chooses two participators for each session to browse the flood preparedness module (Total 5 session).
2. Each evaluation, the usability idea, and the task situations that must be resolved are briefly explained to the participants. Researchers created the task scenario to make sure that each feature, function, and input design could be assessed.
3. The facilitator will pose a straightforward query to uncover the participants' thoughts so that the observer can hear them.
4. Any problems, defects, or elements of the application, regardless of design or function, may be discussed by participants.
5. The researcher writes down any remarks or suggestions in addition to recording the participants' responses.

After the UX Testing, the respondents were interviewed again and posed the same three questions that were asked in the first stage. The researcher recorded the respondents' answers to identify the impact of flood preparedness module.

3. Result and Discussion

The management of flood preparedness module is created based on a serious game method to tackle problems that arose in an interactive manner. Learning-based games or serious gaming tactics have an impact on learning in two ways: first, by directly altering the cognitive process, and second, by subtly increasing motivation [20].

The result from the interview were conducted with ten respondents where they are first year students who are currently living and studying in Shah Alam. 60% of the respondents are staying in flood-prone neighbourhood and only one respondent (10%) has experienced flood hazard. The respondents were asked the same 3 questions before and after accessing the Flood Preparedness Gallery. They were asked

to state a number between 1 to 5 where 1 represents strongly disagree and 5 indicates strongly agree. Figure 5 shows the result of the respondents' answers prior to UX Testing while Figure 6 after the test.

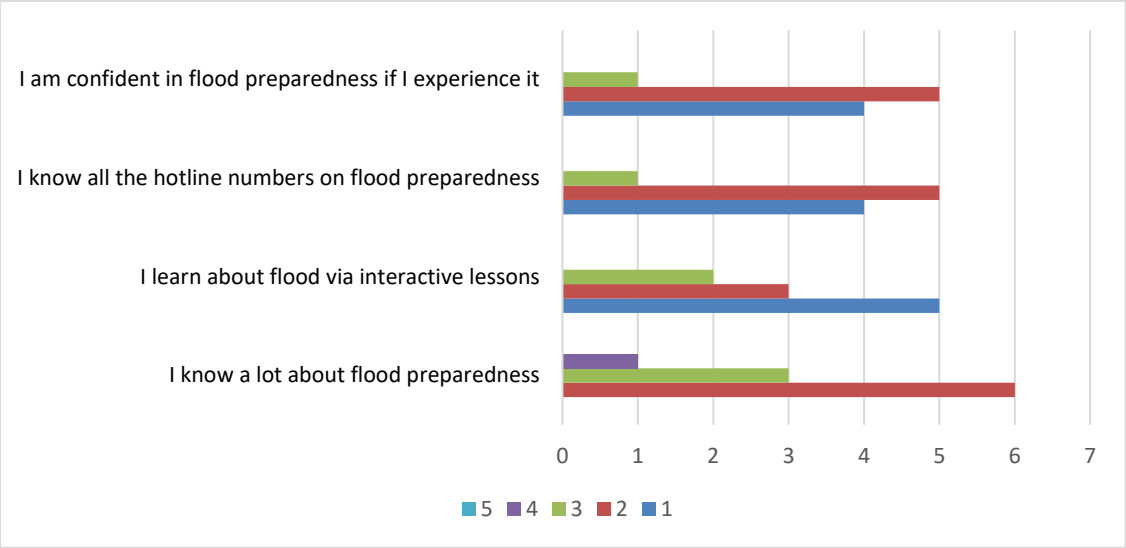


Figure 5. Pre-UX Testing of users' perception on flood preparedness in Malaysia

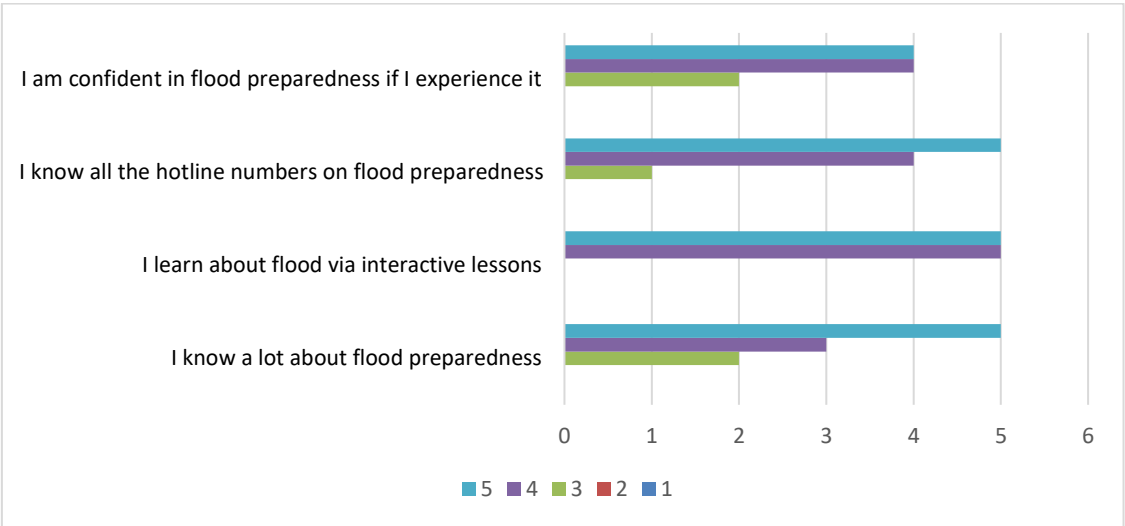


Figure 6. Post-UX Testing of users' perception on flood preparedness in Malaysia

The researcher has recorded and analysed the test findings of user experience using three distinct approaches, including guessability, think aloud, and observation. The data from the respondents was analysed using the flood preparedness application to see whether the responder and the application interface were a good fit. The findings of the user experience testing are displayed in Table 1. The following features and functions need to be enhanced to improve the user experience based on the tasks that users completed:

Table 1. Test Results of UX Flood Preparedness Module

Feature/ Function	**Test Results**
Page Layout	• The gallery display is neat, organised and have easy accessibility due to the space of the gallery area which is suitable for the information provided. The infographic posters can be read clearly. • The choice of visuals and infographics are catchy and appropriate to depict the main topic on flood.
Navigation	• Lack of step-by-step instruction to navigate the module in the virtual gallery. • End-users needs to use secondary device such as their handphones to access the QR codes which lead to the quiz and escape game.
Multiple-choice quiz (Quizizz)	• An interesting quiz with gamification features. • The questions are clearly structured and understood. • The quiz design is interactive, and the choice of graphics are appropriate and scintillating.
Escape Game (Genially)	• Engaging activity that promotes intrinsic motivation. • End-users were able to achieve the mission-based activity with clear instructions. • Fun and interactive design.

3.1. Page Layout

To overcome these feedbacks on page layout, more infographics and posters pertaining to flood preparedness and mitigation in Malaysia will be added. Apart from that, the activities will be placed at the end of the infographics and interactive posters to enable learners have ample time to comprehend the information prior to any form of assessment.

3.2. Navigation

In easing the navigation at the Flood Preparedness Gallery, a step-by-step instruction will be added as a guideline for the end-users to navigate the gallery more effectively. Another way to enhance the ease of navigation is by using hyperlinks instead of perusing secondary devices such as handphone or tablet.

4. Conclusion

Based on the feedback given by the participants, the flood preparedness module fulfils the goal of providing information to participants regarding preparation for flood disasters and the necessary information related to agencies that manage natural disasters. The application developed via Spatial.io, a metaverse-based platform provides a nascent, immersive experience for the participants. This is successfully carried by browsing through galleries filled with immersive hazard knowledge related to flood disaster preparedness. The use of Metaverse escalated students' interests and knowledge where 80% of the participants could answer the questions easily after the gallery walk-through. The integration of serious gaming through the escape game piqued the students' motivation and persevered to complete the given mission and overall, the participants were very excited when using this flood preparedness module. The level of flood preparedness is determined by the students' intrinsic motivation to immerse in the flood disaster module. More research is needed to determine more activities and Metaverse features in optimising Malaysian higher education awareness in flood preparedness.

5. References

[1] Shariff N N and Hamidi Z S 2019 Community-based approach for a flood preparedness plan in Malaysia *Jàmbá: J. Disaster Risk Studies* **11** 1 pp 1-6
[2] Department of Statistics Malaysia 2022 Jan [cited 2022 Aug 25] Special report on impact of floods in Malaysia *eStatistic Portal* Available from: https://tinyurl.com/statsflood
[3] Chan N W, Ibrahim A L, Yusoff R and Ismail N A 2002 The significance of stress and other intangible losses during major flood disasters in Malaysia *Disaster management: Strengthening the national security capabilities* pp 160-173
[4] Chan N W 2015 Impacts of disasters and disaster risk management in Malaysia: The case of floods *In Resilience and recovery in Asian disasters* (Tokyo: Springer) pp 239-265
[5] Lombardo M M and Eichinger RW 2000 High potentials as high learners *Human Resource Mgmt.* **39** 4 pp 321-329
[6] Becker S A, Cummins M, Davis A, Freeman A, Hall CG and Ananthanarayanan V. 2017 *NMC Horizon report: 2017 higher education edition* pp 1-60
[7] Nojang E N and Jensen J 2020 Conceptualizing individual and household disaster preparedness: the perspective from Cameroon. *Int. J. Disaster Risk Sci.* **11** 3 pp 333-346
[8] Kohn S, Eaton JL, Feroz S, Bainbridge AA, Hoolachan J and Barnett DJ 2012 Personal disaster preparedness: an integrative review of the literature *Disaster med. and public health preparedness* **6** 3 pp 217-231
[9] López-Marrero T A 2010 An integrative approach to study and promote natural hazards adaptive capacity: A case study of two flood-prone communities in Puerto Rico *Geog. J.* **176** 2 pp 150-163
[10] National Disaster Management Agency 2022 Feb [cited 2022 Aug 25] Ensuring Malaysia's Disaster Preparedness *NADMA website* Available from: https://tinyurl.com/nadmanews
[11] Spyropoulos F, Trichakis I and Vozinaki A E 2022 A narrative-driven role-playing game for raising flood awareness *Sustainability* **14** 1 p 554
[12] Weyrich P, Ruin I, Terti G and Scolobig A 2021 Using serious games to evaluate the potential of social media information in early warning disaster management *Int. J. Disaster Risk Reduction* **56** p 102053
[13] Taylor S and Soneji S 2022 Bioinformatics and the Metaverse: Are we ready? *Frontiers in Bioinformatics* **2**
[14] Khoury M, Gibson MJ, Savic D, Chen AS, Vamvakeridou-Lyroudia L, Langford H and Wigley S. A 2018 A serious game designed to explore and understand the complexities of flood mitigation options in urban–rural catchments *Water* **10** 12 p 1885
[15] Checa D and Bustillo A 2020 A review of immersive virtual reality serious games to enhance learning and training *Multimedia Tools and Applications* **79** 9 pp 5501-5527
[16] Johnson R B and Christensen L 2019 *Educational research: Quantitative, qualitative, and mixed approaches* (Los Angeles: Sage)
[17] Nielsen L, Hansen K S, Stage J and Billestrup J 2015 A template for design personas: analysis of 47 persona descriptions from Danish industries and organizations *Int. J. Sociotech. and Knowledge Development (IJSKD)* **7** 1 pp 45-61
[18] Wouters P, Van Nimwegen, C, Van Oostendorp H and Van Der Spek E D 2013 A meta-analysis of the cognitive and motivational effects of serious games *J. of Edu. Psych.* **105** 2 p 249
[19] Barendregt W, Bekker M M, Bouwhuis D G and Baauw E 2006 Identifying usability and fun problems in a computer game during first use and after some practice *Int. J. Human-Comp. Studies* **64** 9 pp 830-846
[20] Abadi H G N, Peng L Y and Zadeh A M H 2012 Guessability study on considering cultural values in gesture design for different user interfaces *Int. Proceedings Econ. Development & Research* **37**