Application of the System Usability Scale to Prototypes of Tourism and Hospitality Education in Extended Reality of the THETA project

ABSTRACT

This study investigates the usability of extended reality (XR) prototypes in the field of tourism education, focusing on the evaluation through the System Usability Scale (SUS). Framed within the THETA project, a collaboration between the Technological University Dublin, the University of the Balearic Islands, Hotelschool The Hague and Haaga-Helia University of Applied Sciences, the study focuses on four XR prototypes designed to enrich tourism teaching. The prototypes, developed to provide immersive and realistic educational experiences, were evaluated by students from the University of the Balearic Islands using the SUS. The objective was to determine the usability of these prototypes in a real educational context. The results obtained from the SUS indicated high usability, suggesting that the prototypes are suitable for use in tourism educational environments. This finding supports the effectiveness of XR as a pedagogical tool in tourism education and highlights the usefulness of SUS as a reliable method to evaluate the usability of innovative educational technologies. The study contributes to the understanding of how XR technologies can be effectively integrated into the tourism curriculum, opening avenues for future research and practical applications in this field.

***Index Terms*—Extended Reality, Usability, Tourism, Education.**

I. INTRODUCTION

Tourism education faces unique challenges and opportunities in today's era, marked by rapid and changing technological advances. The integration of extended reality (XR) technologies, including augmented reality (AR) and virtual reality (VR), has been identified as a promising avenue to improve teaching and learning in this field. These technologies offer immersive and practical experiences, crucial in tourism education, where understanding of space, environment and customer experience are fundamental. The THETA project (KA220-HED-8C845691), is a collaboration between Technological University Dublin, the University of the Balearic Islands, Hotelschool The Hague and Haaga-Helia University of Applied Sciences. The overall aim of THETA is to prepare students and professionals for a changing profession by offering a versatile, virtual context for real-life case studies, using AR/VR-enabled learning spaces[6]. This project seeks to develop and evaluate XR prototypes to enrich tourism training. The usability of these emerging technologies is a primary concern, especially in an educational environment where users vary in their technological familiarity and competence. In this context, the System Usability Scale (SUS), a quick and reliable evaluation tool to measure usability, becomes an invaluable instrument. The SUS provides a quantitative view of ease of use and user satisfaction, essential aspects for the effective adoption of any new technology [8].

This study focuses on the application of SUS to evaluate the usability of four XR prototypes developed within the framework of the THETA project. These prototypes were designed to simulate diverse and educationally rich tourism experiences, encompassing a range of scenarios and activities common in tourism. By evaluating the usability of these prototypes with students from the University of the Balearic Islands, the study seeks to answer a fundamental question:

Are the prototypes created in the THETA project with XR technologies usable tools for teaching in tourism and hospitality?

The answer to this question has significant implications not only for tourism education but also for the widespread use of XR in higher education. Therefore, this article not only presents the results of the usability evaluation but also discusses the broader implications of the adoption of XR in tourism education, offering perspectives for future research and educational practices.

This work is organized as follows: the methodology in Section **II**. Then, in Section **III**, we describe the results obtained. In Section **IV**, we discuss the main findings of this study, finishing with the conclusions and future work in Section **V**.

II. METHODOLOGY

A. Study Design

This study was designed to evaluate the usability of XR prototypes in tourism education, using the SUS as a measurement tool [7, 8]. The SUS can be applicable over a wide range of systems [1]. The research focused on four XR prototypes developed as part of the THETA project. These prototypes were designed to offer enriched educational experiences in different areas of tourism.

B. Prototype Selection

The XR prototypes selected for this study represented different aspects and experiences related to tourism education, such as the visualization of a hotel room, a hologram of a chef, the instructions for the elements of a kitchen, and an upset customer 1. Each prototype was developed to be interactive, immersive and representative of real situations in the field of tourism following an agile methodology these prototypes were developed in the THETA project.

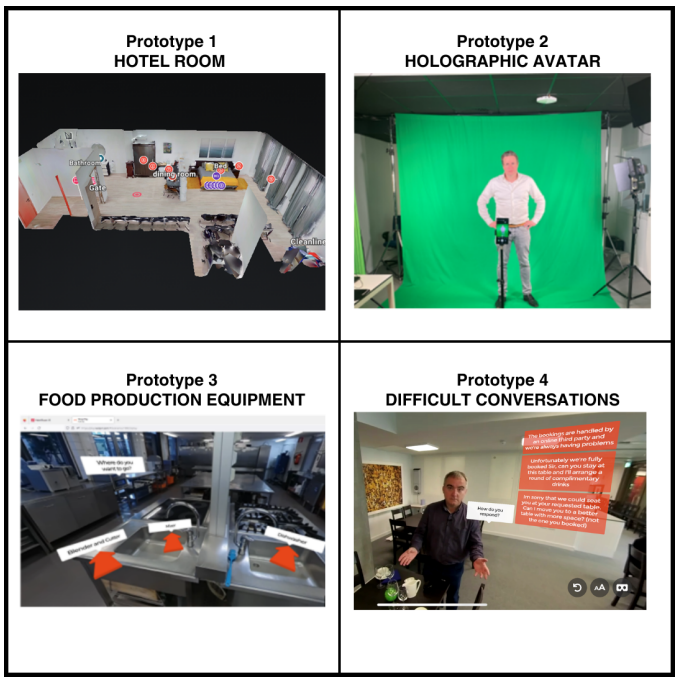

Figure 1. Four prototypes of the THETA project

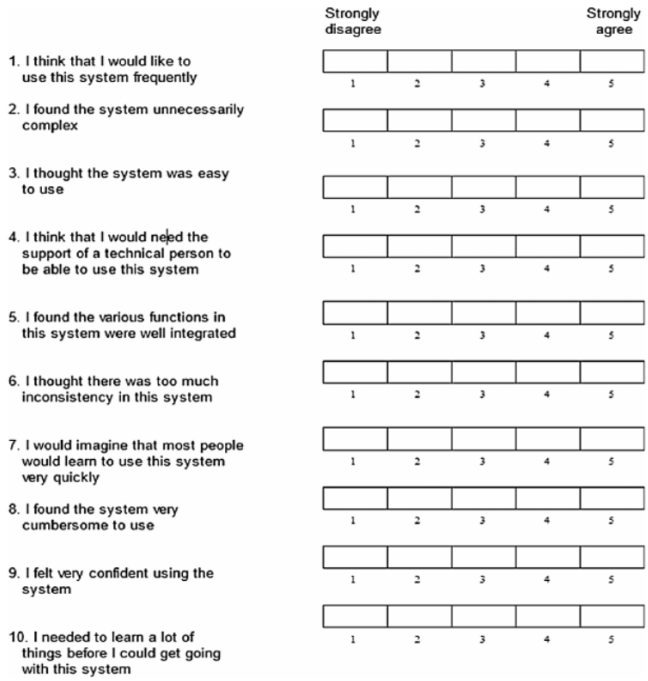

Figure 2. System usability scale ©digital equipment corporation, 1986 (Source: [7])

C. Participants

The participants in this study were 27 students from the Higher Education Institutions (HEI) of the Balearic Islands, from the Faculty of Tourism who are studying the subject of Technology in Tourism. They were introduced to the XR prototypes in a controlled environment, where they were able to interact with each of them in individual sessions.

D. SUS application

The SUS was used to evaluate the usability of the prototypes. This scale consists of a short questionnaire with 10 items, which measures different aspects of usability, such as ease of use, efficiency and general user satisfaction. Each participant completed the SUS after interacting with each prototype. Responses were rated on a 5-point Likert scale, from "Strongly Disagree" to "Strongly Agree." Following the application of SUS [7].The SUS questionnaire format and questions can be seen in Figure 2.

E. Data analysis

Data collected from the SUS were analyzed using standard statistical methods to determine the perceived usability of each prototype. SUS scores were calculated according to established methodology, with each item contributing to a total usability score from 0 to 100. This analysis provided a quantitative assessment of ease of use and user satisfaction with the evaluated prototypes.

F. Ethical Considerations

Confidentiality and anonymity were assured in the processing of their responses and personal data, as well as their consent to carry out this study.

III. Results

SUS scores were calculated following the scoring instructions [7] for each participant's responses. The SUS results indicated that the students perceived the XR prototypes as usable. The mean SUS scores for the four prototypes were as follows:

Table I
RESULTS OF SUS SCORES FOR THE FOUR PROTOTYPES

Prototype	SUS Score
Prototype 1:	82.4
Prototype 2	53.9
Prototype 3	70.3
Prototype 4	70.2

These scores suggest that the prototypes were perceived as mostly usable and Prototype 1 received the highest evaluation. In [3, 4] used an adjective scale by dividing the SUS scores as follows: score of 0–25: worst, score of 25–39: poor, score of 39–52:OK, score of 52–85: excellent, and score of 85–100: best imaginable. In Table II we can see the rating of the prototypes using this scale.

Table II
RATING SCALE OF THETA PROTOTYPES

Prototype	Adjective Rating
Prototype 1:	excellent
Prototype 2	excellent
Prototype 3	excellent
Prototype 4	excellent

A. Analysis of Individual Items

When breaking down the responses to the individual SUS items, a general trend was observed towards positive responses on aspects such as ease of learning and user satisfaction. For example, in the item "I think I would like to use this system frequently", 81% of the participants responded affirmatively for Prototype 1, while 66% did so for Prototype 4. This result is probably due to the fact that the prototype 4 requires Google Cardboard, a low-cost glass for virtual reality with phones.

B. Comparison between Prototypes

When comparing the prototypes, it was found that Prototype 3 and 4, which offered a more immersive experience in VR, scored higher in terms of user satisfaction and ease of use. In contrast, Prototype 2, which focused more on AR and needed an additional step, the positioning of the hologram, received slightly lower evaluations, possibly due to the loss of dimensionality of the hologram in AR.

C. Differences in Usability Perception

Significant differences in usability perceptions were served between the prototypes, suggesting that the design and content focus of XR influence how users perceive its ease of use and usefulness. Prototypes that featured more intuitive interactions and different options to change immersive views tended to obtain higher scores.

D. Statistical Interpretation

Statistical interpretation of the SUS results showed a standard variation in scores between prototypes. The analysis of variance (ANOVA) [12] revealed that the differences in usability scores were statistically significant ($p < 0.05$), suggesting that the variations in perceived usability were not random and could be attributed to the specific characteristics of each prototype.

E. Comparison with Previous Studies

Our findings are in line with previous studies that emphasise the importance of usability in the adoption of learning technologies [2, 5, 6, 9–11]. The correlation between high usability and a positive learning experience highlights usability not only as a technical measure but also as a key component in the pedagogical effectiveness of XR technology.

IV. Discussion

The evaluation of the XR prototypes through the SUS revealed a generally positive perception of their usability. The high scores obtained, especially for Prototype 1, suggest that XR can be an effective and well-accepted tool in tourism education. However, variations in scores between prototypes indicate that certain aspects of design and functionality significantly affect the user experience. When performing an analysis of the responses to the individual items of the SUS, it points to the importance of ease of learning and general satisfaction with the usability of the XR prototypes. Prototypes that offered an intuitive and contextually relevant user experience for tourism students achieved greater acceptance. This underscores the need for user-centered design in the development of XR educational tools, where familiarity and relevance of content are crucial. Additionally, the results of the study have significant implications for the integration of XR in tourism education. The high perceived usability of the prototypes indicates a potential to improve the quality of teaching and learning experience, offering realistic simulations and interactive contexts that are difficult to replicate in traditional environments. It is important to note that although the prototypes were generally well received, the lower scores on certain prototypes suggest areas for improvement. Specifically, aspects such as interface complexity and learning curve affected the perception of usability. This indicates that XR design for tourism education must balance immersion and interactivity with simplicity and accessibility.

V. Conclusions

This study contributes to understanding how XR can enrich tourism teaching at HEIs and offers insights for its broader use in education. The findings underline the importance of careful, user-centered design and suggest great potential for future research and development in this field thanks to the acceptance of the THETA project prototypes. The overall SUS scores indicate that the XR prototypes are highly usable in the HEI tourism educational context. In particular, prototypes that offer immersive and relevant experiences for tourism students were the highest rated. Additionally, the results suggest that XR can be a valuable pedagogical tool in tourism education, providing rich and contextual learning experiences that can overcome the limitations of traditional methods. The expansion of the use of XR in tourism education and possibly other fields opens a door to future research that could explore how different XR designs and approaches can further enhance the learning experience.

References

[1] P. T. K. Aaron Bangor and J. T. Miller. An empirical evaluation of the system usability scale. *International Journal of Human–Computer Interaction*, 24(6):574–594, 2008.

[2] P. Arpaia, E. De Benedetto, L. De Paolis, G. D'Errico, N. Donato, and L. Duraccio. Performance and usability evaluation of an extended reality platform to monitor patient's health during surgical procedures. *Sensors*, 22(10):3908, 2022.

[3] F. Bakhshi-Raiez, N. de Keizer, R. Cornet, M. Dorrepaal, D. Dongelmans, and M. Jaspers. A usability evaluation of a snomed ct based compositional interface terminology for intensive care. *International Journal of Medical Informatics*, 81(5):351–362, 2012.

[4] A. Bangor, P. Kortum, and J. Miller. Determining what individual sus scores mean: Adding an adjective rating scale. *J. Usability Studies*, 4(3):114–123, may 2009.

[5] C. Barreto-Paredes, D. Agudo, M. F. Granda, and O. Parra. Evaluating extended reality application for a virtual museum. case study: Remigio crespo museum. In *2022 Third International Conference on Information Systems and Software Technologies (ICI2ST)*, pages 49–56. IEEE, 2022.

[6] B. Bermejo, C. Juiz, D. Cortes, J. Oskam, T. Moilanen, J. Loijas, P. Govender, J. Hussey, A. L. Schmidt, R. Burbach, D. King, C. Connor, and D. Dunlea. Ar/vr teaching-learning experiences in higher education institutions (hei): A systematic literature review. *Informatics*, 10(2), 2023.

[7] J. Brooke. Sus: a "quick and dirty'usability. *Usability evaluation in industry*, 189(3):189–194, 1996.

[8] J. Brooke. Sus: a retrospective. *Journal of usability studies*, 8(2):29–40, 2013.

[9] R. Dutta, A. Mantri, G. Singh, A. Kumar, and D. P. Kaur. Evaluating usability of mobile augmented reality system for enhancing the learning experience. In *2021 Sixth International Conference on Image Information Processing (ICIIP)*, volume 6, pages 180–185. IEEE, 2021.

[10] M. H. Ronaghi. The effect of virtual reality technology and education on sustainable behavior: A comparative quasi-experimental study. *Interactive Technology and Smart Education*, (ahead-of-print), 2022.

[11] M. Rzeszewski and M. Orylski. Usability of webxr visualizations in urban planning. *ISPRS International Journal of Geo-Information*, 10(11), 2021.

[12] L. St, S. Wold, et al. Analysis of variance (anova). *Chemometrics and intelligent laboratory systems*, 6(4):259–272, 1989.