Human Factors and Wearable Technologies, Vol. 175, 2025, 72–77
https://doi.org/10.54941/ahfe1006360

Exploring the Potential of Note-Taking in Mixed Reality as Applied to Field-Based Learning

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ABSTRACT

This study aims to compare the effectiveness of mixed reality, pen and paper, and digital note-taking in the context of educational excursions. A mixed reality headset was used to take notes in mixed reality, mobile phones for taking notes digitally, as well as pen and paper paired with a clipboard for taking notes in longhand. The study was motivated by the potential affordances that mixed reality brings to note-taking, such as integrating the real world alongside digital note-taking platforms in an immersive manner. However, there are also downsides, such as the bulkiness of the headset. While existing research has covered virtual reality and augmented reality within classroom settings, there remains a gap in current research in understanding the application of mixed reality in contexts outside of the classroom, such as in field-based learning. To address this, this study aims to conduct preliminary research on how note-taking in mixed reality compares with two other traditional methods in a new context to understand the potential of mixed reality and its feasibility in note-taking and learning. Educational excursions were chosen as it was surmised that the affordances of mixed reality headsets are suited to contexts of learning during which the note-taking platform needs to be mobile. The modalities of information students could encounter in a field trip were recognised as physical, textual, and video. For physical information in field trips, our data shows that mixed reality note-taking was more effective in both extracting greater amounts of content in note form, as well as improving knowledge retention. For textual information, mixed reality note-taking was also more effective in extracting greater amounts of content in note form, but pen and paper note-taking was the more efficacious method in the organisation of notes. Mixed reality has the potential to be integrated into field trips, but should not entirely replace traditional methods of note-taking, especially as feedback from participants shows that the headsets can cause discomfort. As the comfort of wearables improves, more research can be carried out to continue this work on the potential of mixed reality in collaborative learning.

Keywords: Mixed reality, Note-taking, Apple vision pro, Educational excursions, Field trips

INTRODUCTION AND AIM

While existing research has covered virtual reality and augmented reality within classroom settings, there remains a gap in current research in

understanding the application of mixed reality in contexts outside of the classroom, such as in field-based learning. Understanding the specific impacts of mixed reality on educational excursions could help create better field trips for effective learning in the future. Hence, the present study aimed to investigate the effectiveness of mixed reality note-taking compared to traditional pen and paper and digital methods during educational excursions. We hypothesise that mixed reality note-taking will be the superior method in at least one area and thus has potential to be integrated into field trips.

LITERATURE REVIEW

The evaluation of the quality of notes can be understood according to the following criteria. First, the quantum/amount of content comprising notes taken in mixed reality, as compared to traditional methods. This could be helpful in the context of field trips, where post-trip activities have been proven to improve effectiveness of field trips (Lee et al., 2020), as more content means more materials to utilise for the activities. Second, the organisation of notes is also important – according to Kiewra and Dubois (Kiewra and Dubois, 1998) who referenced Chen (Chen et al., 2016), it is an important feature of effective notes. Not only that, according to Makany (Makany et al., 2009) who referenced Titsworth and Kiewra (Titsworth and Kiewra, 2004), the organisation of notes has several benefits in learning. Beyond merely the notes taken, we examine how mixed reality affects factual recall and conceptual understanding compared with other methods, as previous studies on note-taking commonly focus on the latter (for example, Mueller and Oppenheimer, 2014). Since mixed reality has been shown to improve the motivation and engagement of participants, this could suggest it has positive effects on factual recall, or on knowledge retention abilities, making it a worthy area of investigation (Sviridova et al., 2023). The present study therefore applies knowledge retention as the third criterion, and critical thinking as the fourth.

METHODOLOGY

The study explored three distinct scenarios commonly encountered during educational excursions. The first involved learners observing real-world phenomena or objects in their environment (physical). The second focused on learners engaging with textual information provided to them (textual), while the third examined situations during which learners process auditory or video content (video). For each scenario, participants were split into three groups: the first group used Apple Vision Pro headsets, each paired with a Bluetooth keyboard, members of the second group were each given a clipboard, paper, and a pen, and the third group utilised their personal smartphones for note-taking. After each scenario, a quiz was administered to measure the knowledge retention and critical thinking of the participants. Participants also rated their prior knowledge of the topic from 1 to 10. At the end, participants completed a feedback form on their opinion of the methods. In total, 50 students in grades 7 through 12 were recruited.

MEASURES TO ASSESS EFFECTIVENESS OF NOTES

The notes were graded to give 2 scores. The N-score is a percentage of the total idea units identified by the participant, whereas the organisation-score (O-score) is a rating between 0–5. The O-score is subjectively rated, and is based upon the legibility and organisation of the notes.

The quiz was conducted to assess knowledge retention and critical thinking. Previous studies (Bissell and Lemons, 2006) used Bloom's Revised Taxonomy (Anderson and Krathwohl, 2001) to define critical thinking. This study referenced this approach for setting and grading questions to ensure the learning objectives of testing knowledge retention and critical thinking were clearly defined. For Scenario 1 (physical), the quiz had one question. It was graded to give the KR-score, which measures knowledge retention, and the CT-score, which measures critical thinking. For Scenarios 2 and 3 (textual and video, respectively), the quiz had five questions. Three were factual questions and two were conceptual questions. The marks for all three factual questions were added together to give the FA-score, while the marks for both conceptual questions were divided by their full mark respectively to give the C1-score and C2-score.

RESULTS

For this paper, we focus on reporting the results from Scenarios 1 and 3.

Scenario 1 (Physical)

I. NOTES

One-way analysis of variance was conducted to compare the effect of note-taking methods on the N-score. It revealed a statistically significant difference in N-scores between at least two groups ($F(2, 23) = 5.422$, $p = 0.012$). A post hoc Tukey-Kramer test found that the N-score was significantly higher for mixed reality note-takers than that of pen and paper note-takers (mean difference = 14.708, $p = 0.017$, 95% C.I. = [2.439, 26.977]), as well as for mixed reality note-takers than that of phone note-takers (mean difference = 15.438, $p = 0.017$, 95% C.I. = [2.186, 28.689]). There was no statistically significant difference in N-scores between phone note-takers and pen and paper note-takers ($p = 0.985$, 95% C.I. = [−11.929, 10.471]).

The Kruskal-Wallis test was used to analyse the effect of the note-taking method on the O-score. It revealed there was no statistically significant difference in O-score amongst the groups (Chi square = 2.339, $p = 0.311$, $df = 2$).

II. QUIZ

In Scenario 1 (physical), the quiz question was graded to give the KR-score, which measures knowledge retention, and the CT-score, which measures critical thinking. The square of the Pearson correlation coefficient was calculated to reveal no statistically significant correlation between prior knowledge and quiz scores.

The Kruskal-Wallis test was used to analyse the effect of note-taking methods on the KR-score. It revealed a statistically significant difference in KR-score between at least two groups (Chi square = 6.946, $p = 0.031$, $df = 2$). A post hoc Dunn's test with p-values adjusted with the Bonferroni

method found that the KR-score was significantly higher for mixed reality note-takers than pen and paper note-takers ($z = 2.477$, $p = 0.040$), as well as for mixed reality note-takers than phone note-takers ($z = 2.287$, $p = 0.067$). There was no statistically significant difference in KR-scores between pen and paper note-takers and phone note-takers ($z = -0.133$, $p = 1.000$).

The Kruskal-Wallis test was used to analyse the effect of note-taking methods on the CT-score. It revealed there was no statistically significant difference in the CT-scores amongst the groups (Chi square = 5.268, $p = 0.072$, $df = 2$).

Scenario 3 (Video)

I. NOTES

One-way analysis of variance was conducted to compare the effect of note-taking methods on the N-score. It revealed there was no statistically significant difference in N-scores amongst the groups ($F(2, 31) = 1.277$, $p = 0.293$).

The Kruskal-Wallis test was used to analyse the effect of the note-taking method on the O-score. It revealed there was no statistically significant difference in O-scores between the groups (Chi square = 0.025, $p = 0.988$, $df = 2$).

II. QUIZ

The marks for all three factual questions were added together to give the FA-score, while the marks for both conceptual questions were divided by their full mark respectively to give the C1-score and C2-score. The square of the Pearson correlation coefficient was calculated to reveal no statistically significant correlation between prior knowledge and quiz scores.

The Kruskal-Wallis test was used to analyse the effect of note-taking methods on the FA-score. It revealed there was no statistically significant difference in FA-scores amongst the groups (Chi square = 0.632, $p = 0.729$, $df = 2$).

The Kruskal-Wallis test was used to analyse the effect of note-taking methods on the C1-score. It revealed there was no statistically significant difference in C1-scores amongst the groups (Chi square = 2.081, $p = 0.353$, $df = 2$).

The Kruskal-Wallis test was used to analyse the effect of note-taking methods on the C2-score. It revealed there was no statistically significant difference in C2-scores amongst the groups (Chi square = 0.537, $p = 0.765$, $df = 2$).

DISCUSSION

For scenario 1 (physical), the data collected suggests that all note-taking methods were equally effective in organisation of notes as well as facilitating critical thinking. However, mixed reality note-taking was the most effective note-taking method in terms of capturing more idea units, as well as facilitating knowledge retention. Since mixed reality note-taking was the most effective note-taking method in terms of capturing more idea units, this implies that mixed reality note-taking might be a viable method if teachers are aiming for students to add more content to field notes. Previous studies

have pointed out that post-trip activities, such as discussions or specific lessons related to the content (Lee et al., 2020), are important factors for ensuring positive student outcomes during field trips. Hence, the usage of mixed reality note-taking could then further enhance these post-trip activities by facilitating the addition of more content to field notes, so educators and students could have more comprehensive post-trip reviews. Similarly, since mixed reality note-taking is the most effective note-taking method in terms of facilitating knowledge retention, this implies that mixed reality note-taking might be a viable method if teachers hope for students to retain more knowledge. Previous studies have suggested that immersive technologies improve the motivation and engagement of participants (Sviridova et al., 2023). Likewise, in this study, when choosing which participants to use for each study, many participants actively volunteered to use the Apple Vision Pro mixed reality headset. A learner's interest and desires are the factors that lead them to exhibit flexibility, problem solving, and more efficient knowledge acquisition (Mulang, 2021). The participants' interest in immersive technologies would have led them to exhibit such traits during the note-taking process, encouraging deeper interaction with the material, which may explain why mixed reality note-taking was found to be more effective for knowledge retention. For scenario 3 (video), the data collected suggests that all note-taking methods were equally effective in capturing idea units, organisation of notes, facilitating knowledge retention, as well as facilitating critical thinking. Overall, the study suggests the mixed reality note-taking has potential to be integrated into field trips for purposes of capturing more information and encouraging knowledge retention in physical scenarios, supporting our initial hypothesis.

We acknowledge that taking notes using the Apple Vision Pro in a physical setting is challenging, as it requires the user to balance many activities. Feedback from participants included the weight of the headsets, and eye strain due to the blurred projection of the physical environment, which might potentially cause discomfort or nausea when used for longer periods of time. The virtual keyboard and eye setups were described as "janky" and "inconsistent", which made typing and selecting options challenging. Besides that, participants reported issues about the responsiveness of the device, and how it was "discombobulating" to walk around with the headset on for long periods of time. Positive feedback included the participants identifying a number of affordances: namely, the efficiency of the operating system of the headset, its integration with reality, and its portability. By 'efficiency', participants appreciated being able to work in several windows at the same time, placing screens anywhere in their view, making it easier to multitask. Participants brought up helpful features on the headset, like autocorrect, the large screen size, and the ability to draw or annotate without physical interaction.

CONCLUSION

Mixed reality has the potential to be integrated into field trips, especially for physical observation segments, to increase quality of notes and knowledge

retention, but should not entirely replace traditional methods of note-taking. Traditional note-taking methods should also still be utilised, especially in scenarios where they're equally effective as the Apple Vision Pro, but are more comfortable and less costly. There is also much potential for further research in the potential of mixed reality for note-taking, such as for how collaborative learning can be enhanced. Our study focused on individual note-taking without outside influence. However, mixed reality allows collaboration in the virtual world, which could prove significantly beneficial for learning and student-teacher interactions during field trips.

ACKNOWLEDGMENT

The authors would like to acknowledge Mr. Ahmed Hazyl Hilmy for his numerous meetings to discuss our project focus, his support during the data collection process, and his invaluable writing assistance. We also express our sincere appreciation to everyone who played a role, directly or indirectly, in supporting this study.

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