Discussion

Using 3D models to increase students' engagement in geoscience teaching

Johanna Anjar[1], Andreas Falck[2], Endre Før Gjermundsen[3], Alastair C. Goodship[1], Julie Guttormsen[4], Oliver Wøbbe Kristensen[1]

[1] Department of Natural Sciences and Environmental Health, University of South-Eastern Norway, Norway
[2] Department of Special Needs Education, University of Oslo, Norway
[3] Department of Economics and IT, University of South-Eastern Norway, Norway
[4] Department of Mathematics and Science Education, University of South-Eastern Norway, Norway

Summary: In recent years, the use of virtual 3D models and full virtual excursions has become increasingly common in geoscience education. The integration of LiDAR sensors in the latest iPhone and iPad PRO models, along with the development of apps like Scaniverse that utilize these sensors, has simplified the creation of 3D models of geological features, making the process faster, easier, and more cost-effective. This study examines the impact of these models on student engagement and short-term memory recall. Our findings indicate a clear positive effect on student engagement and perceived learning, although no significant impact on short-term memory recall was observed.

Key words: 3D, virtual, geology, Scaniverse

1 Introduction

Fieldwork is often a key part of geoscience education but comes with logistical, financial, climatic, and accessibility challenges. To address these issues, various virtual alternatives have been developed to replace or complement fieldwork (e.g. Hurst 1998, Senger et al. 2020, Betlem et al. 2023). However, creating effective virtual alternatives

has generally been expensive, time-consuming, and required advanced technical knowledge.

With the integration of LiDAR sensors in iPhone 12 and later models, and the development of apps such as Scaniverse that utilize these features, it has become much easier to create high-quality 3D models of small outcrops (Luetzenburg et al., 2021). These models can be integrated into lectures or exercises, used as field documentation, or combined into virtual field courses.

In this pilot study, we tested the effects of such 3D models on student engagement and short-term memory recall.

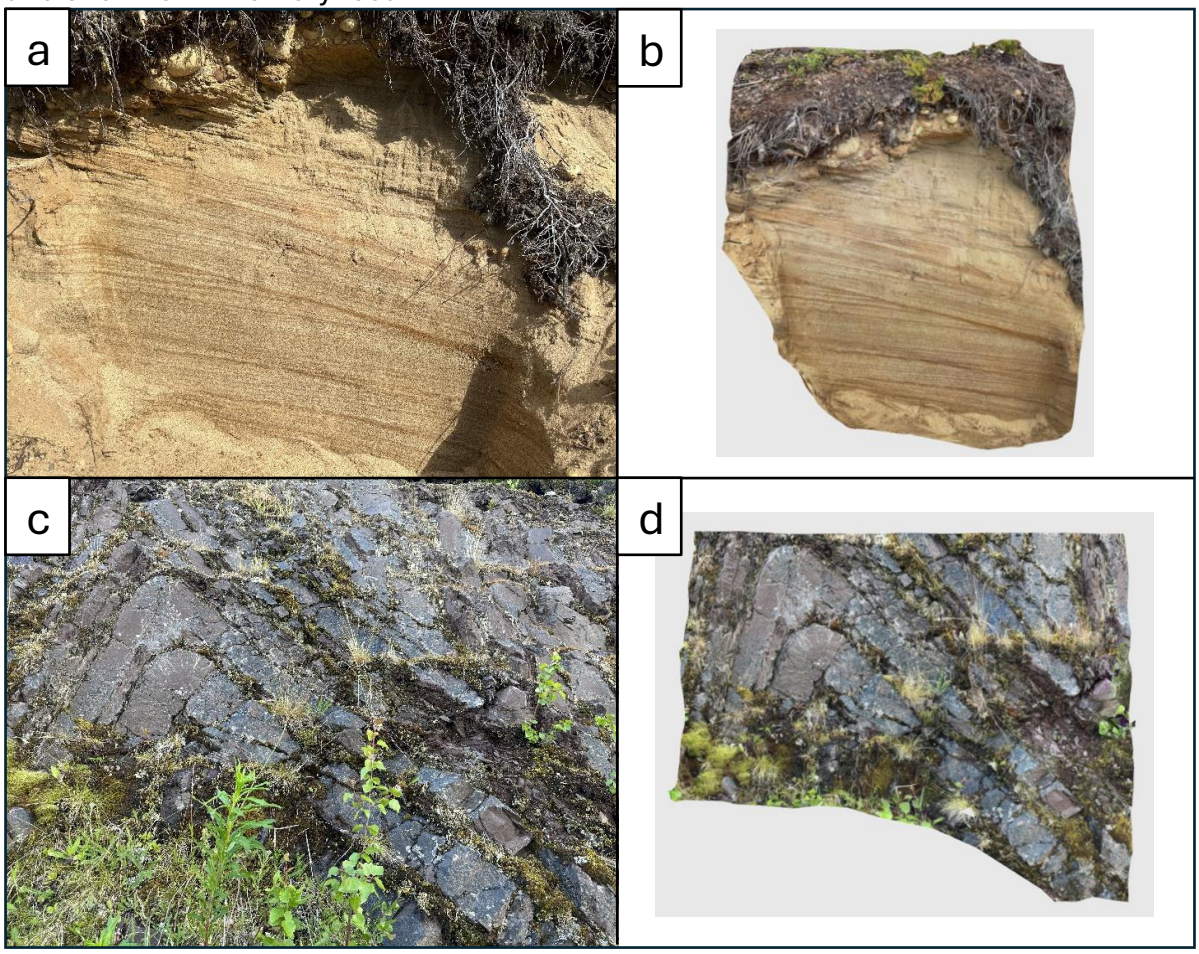


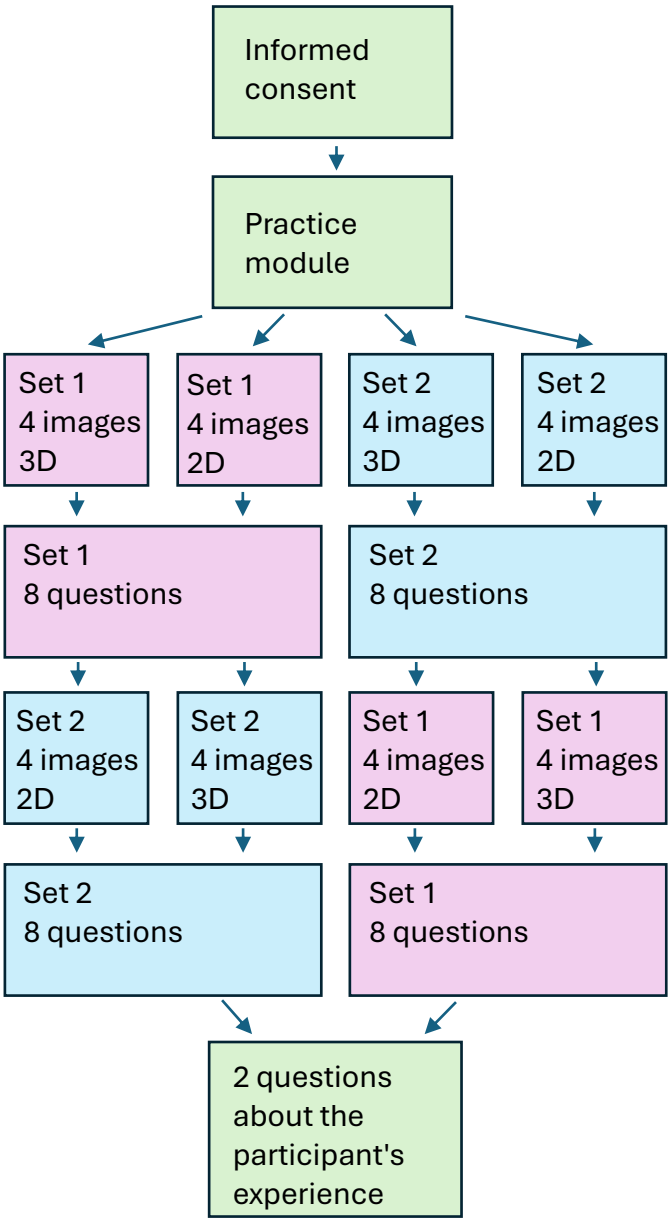
Figure 1. Examples of the images used in the experiment. A and b show the same sediment section in 2D (a) and 3D (b). C and d show the same fold in 2D (c) and 3D (b). The 3D images can be seen in 3D at https://skfb.ly/ptUVn (b) and https://skfb.ly/ptUVr (d).

2 Methods

2.1 Creation of the 3D models

The 3D models were created using an iPhone 14 PRO and the Scaniverse app. These allow for a fast and user-friendly way to create realistic 3D models. In addition, a normal 2D photo was taken of each feature to act as a comparison.

2.2 Experimental setup



Thirty-nine students enrolled in an introductory geology course participated in the experiment. The participants were presented with two sets of four images depicting geological features: one set in 3D and the other in 2D. After viewing each set, the students answered eight questions related to the images. Some questions referred directly to the visual content, while others required related information, such as the name of the feature, which was displayed alongside the image. None of the questions required an understanding of the 3D properties of the features. Once the students began answering the questions, they could not revisit the images. The primary aim of the questions was to assess any differences in short-term recall based on whether the images were viewed in 2D or 3D. No personal data was collected during the experiment. Refer to Figure 2 for a visualization of the experimental setup.

Figure 2. Experimental set up. To balance the experiment four different variations were used.

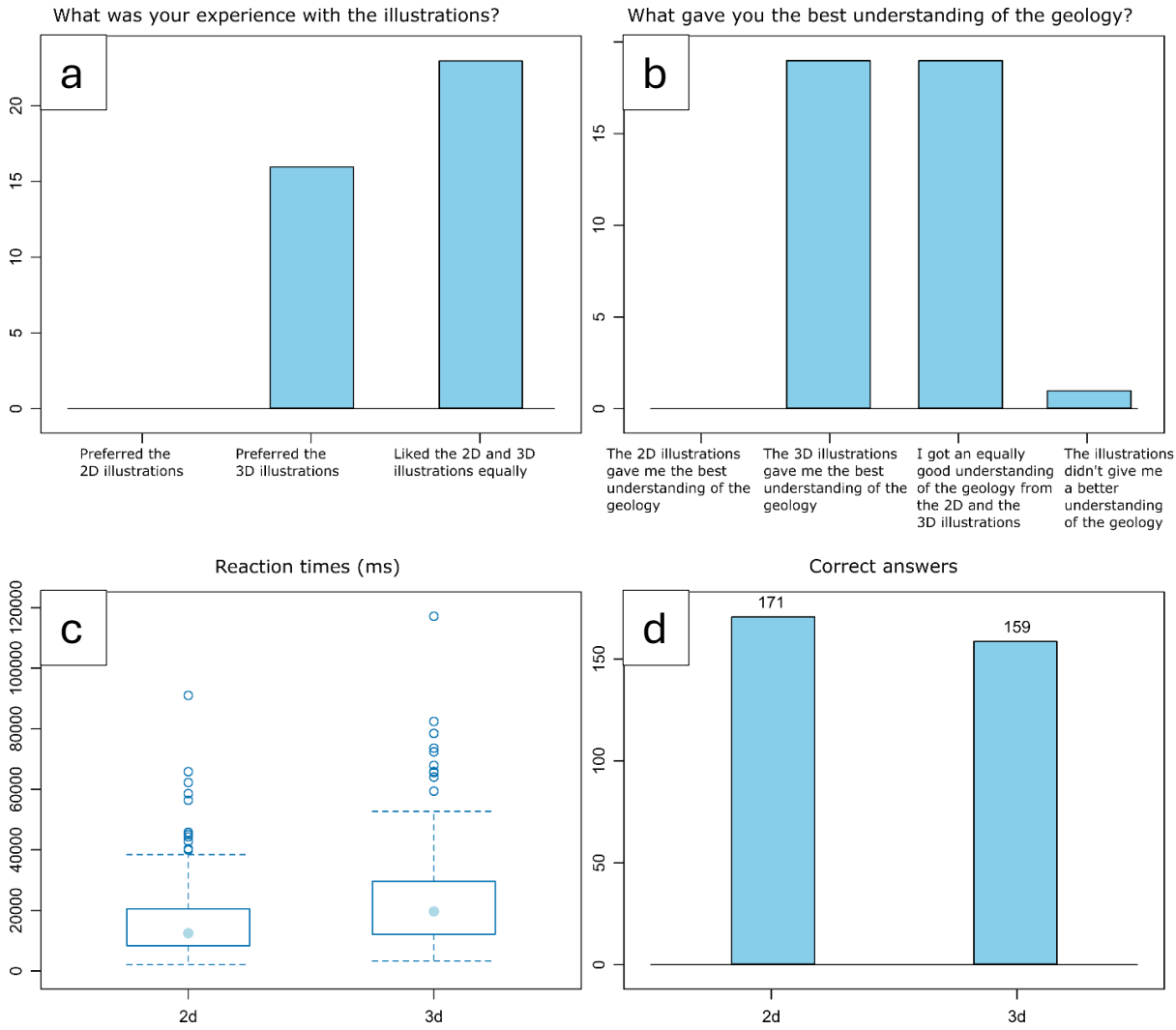


Figure 3. Experiment results. A and b are the result of questions regarding the students' preferences and perceived learning, c, shows the time spent on each 2D and 3D image, d is the number of correct answers associated with 2D vs 3D images. Note that the experiment was balanced so that the total number of questions in each category is the same.

3 Results

All our measures of student engagement favoured the 3D models. When asked, students either preferred the 3D models (n=16) or liked both the 2D and 3D illustrations equally (n=23); no one preferred the 2D illustrations (Figure 3a). When asked which illustrations they thought gave them the best understanding of the geology, 19 students chose the 3D models, while another 19 believed that both the 2D and 3D models offered equal understanding; no one felt they learned more from the 2D illustrations (Figure 3b).

Analysing reaction times, i.e. the time students spent on each image, we found that they spent significantly more time on the 3D illustrations, averaging 24.8 seconds, compared to 16.6 seconds on the 2D illustrations (Figure 3c). However, when examining the results of the associated geology questions, we observed no significant difference

between the questions linked to 2D illustrations and those linked to 3D illustrations. If anything, students performed slightly worse on the questions related to the 3D images (Figure 3d).

4 Discussion

Our experiment shows that 3D illustrations are effective in engaging students with the material, but that this engagement does not necessarily translate into increased learning. However, this does not imply that 3D models can never enhance learning. In our pilot study we designed the experiment so that neither the 2D nor the 3D images had any inherent advantages related to the questions asked. Any differences in responses would then stem from variations in short-term memory recall based on student engagement with the material. As shown in Figure 3c, no such effect was observed.

If the 3D models are used to demonstrate aspects that are easier to interpret in 3D, or to provide a more realistic or engaging demonstration, the result may well be different. For instance, Bond and Cawood (2021) found improved 3D thinking when students were shown a virtual 3D model of a fold.

5 Conclusions

- Using the Scaniverse app and the LiDAR sensor built into the newer iPhone PRO models is a fast and easy way to generate realistic 3D models of geological features that can be used in lectures, exercises, or as field documentation.
- The 3D models had a clear positive effect on student engagement. The students preferred them to the 2D imagery, thought they learnt more, and spent more time on them.
- However, we found no improvement in how well the students recalled information connected to the 3D imagery compared to the 2D imagery.
- We conclude that these models are great for engaging students or to make an exercise more realistic, but that they are not in themselves enough to improve learning.

Acknowledgements

This study was supported by the University of South-Eastern Norway.

References

Betlem, P., Rodés, N., Birchall, T., Dahlin, A., Smyrak-Sikora, A., & Senger, K., 2023, Svalbox Digital Model Database: A geoscientific window into the High Arctic: Geosphere, v. 19, no. 6, p. 1640–1666, https://doi.org/10.1130/GES02606.1.

Bond, C. E. and Cawood, A. J. 2021, A role for virtual outcrop models in blended learning – improved 3D thinking and positive perceptions of learning, Geosci. Commun., 4, 233–244, https://doi.org/10.5194/gc-4-233-2021,

Hurst, S. D. 1998, Use of "virtual" field trips in teaching introductory geology, Computers & Geosciences 24, p. 653-658, https://doi.org/10.1016/S0098-3004(98)00043-0.

Luetzenburg, G., Kroon, A. & Bjørk, A.A. 2021, Evaluation of the Apple iPhone 12 Pro LiDAR for an Application in Geosciences. *Sci Rep* 11, 22221. https://doi.org/10.1038/s41598-021-01763-9

Senger, K., Betlem, P., Birchall, T., Buckley, S. J., Coakley, B., Eide, C. H., Flaig, P.P., Forien, M., Galland, O., Gonzaga Jr., L., Jensen, M., Kurz, T., Lecomte, I., Mair, K., Malm, R. H., Mulrooney, M., Naumnann, N., Nordmo, I., Nolde, N., Ogata, K., Rabbel, o., Schaaf, N. W. & Smyrak-Sikora, A. (2020). Using digital outcrops to make the high Arctic more accessible through the Svalbox database. Journal of Geoscience Education, 69(2), 123–137. https://doi.org/10.1080/10899995.2020.1813865.