

Danish University Colleges

Augmented Reality for Science Education

Brandt, Harald; Nielsen, Birgitte Lund; Georgsen, Marianne; Swensen, Håkon

Publication date:
2015

Document Version
Pre-print: The original manuscript sent to the publisher. The article has not yet been reviewed or amended.

[Link to publication](#)

Citation for published version (APA):

Brandt, H., Nielsen, B. L., Georgsen, M., & Swensen, H. (2015). Augmented Reality for Science Education. Poster session presented at EC-TEL 2015 Tenth European Conference on Technology Enhanced Learning, Toleda, Spain.

General rights

Copyright and moral rights for the publications made accessible in the public portal are retained by the authors and/or other copyright owners and it is a condition of accessing publications that users recognise and abide by the legal requirements associated with these rights.

- Users may download and print one copy of any publication from the public portal for the purpose of private study or research.
- You may not further distribute the material or use it for any profit-making activity or commercial gain
- You may freely distribute the URL identifying the publication in the public portal

Download policy

If you believe that this document breaches copyright please contact us providing details, and we will remove access to the work immediately and investigate your claim.

Augmented Reality for Science Education

Harald Brandt¹, Marianne Georgsen², Birgitte Lund Nielsen¹, Håkon Swensen³.

¹VIA University College, Faculty of Education and Social Studies, Aarhus, Denmark
{habr, bnle}@via.dk

²VIA University College, School of Continuing Education, Aarhus, Denmark
mage@via.dk

³Oslo and Akershus University College of Applied Sciences, Faculty of Education and International Studies, Oslo, Norway
Hakon.Swensen@hioa.no

Keywords: Augmented reality; science education; design of AR; student learning; categorization of AR applications

1 Introduction

Augmented reality (AR) holds great promise as a learning tool. So far, however, most research has looked at the technology itself – and AR has been used primarily for commercial purposes. As a learning tool, AR supports an inquiry-based approach to science education with a high level of student involvement. The AR-sci-project [1] (Augmented Reality for SCIENCE education) addresses the issue of applying augmented reality in developing innovative science education and enhancing the quality of science teaching and learning. AR-sci is an ongoing, international project funded by ERASMUS+. AR-sci is aimed at developing augmented reality (AR) for educational purposes, specifically for science education, and in particular for lower secondary school. The poster presents the project and in particular the findings from stage 1 (see overview of project in figure 1 below).

The research activities in stage 1 are aimed at securing project direction and usefulness – to secure that the project builds on solid ground and existing knowledge in the field, you could say. A central part of this is done through a framework which will serve both as a guideline in designing AR-prototypes in the project (“showcase” content), and in providing support for teachers and students as designers and producers of AR in the next stages of the project. Furthermore, the framework might have a wider potential to be used to analyse various kinds of educational use of AR applications. The framework is developed based on rich qualitative data from expert teachers, researchers and designers from the four participating countries Denmark, Norway, UK and Spain.

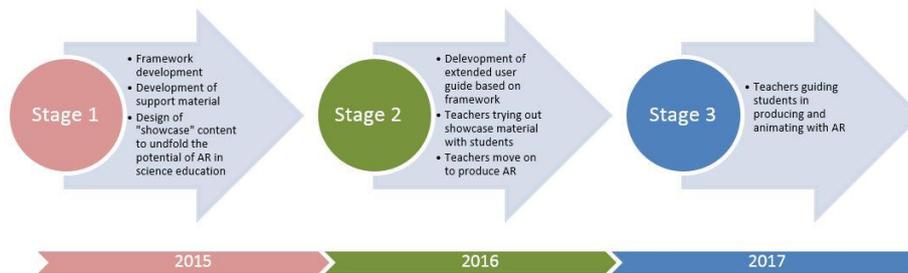


Fig. 1. The 3 stages in the AR-sci project, running 2015-17.

2 Background

AR has been defined on the following three properties [2]:

- It combines real and virtual objects in a real environment
- It runs interactively, and in real time
- It aligns real and virtual objects with each other.

Augmented Reality is often divided into the two categories *marker-less* and *marker-based*. Marker-less AR uses location data such as GPS to identify where the user is and overlay information. Marker-based AR relies on visual markers such as QR codes. Cheng and Tsai [3] supplement these two categories when differing between *location-based* AR and *image-based* AR. Location-based AR is typically marker-less and image-based AR uses pictures as markers – rendered possible by the newest image-recognition technology. For now, these divisions are helpful when designing and developing AR resources in the project. However, technology evolves rapidly and future devices will have more and better sensors for understanding the real world where overlay content is presented. This may cause an increase in the number of categories or lead to a situation where this type of division will be ignored.

Following this brief technical introduction, we wish to focus on how AR technologies can support meaningful learning. Several researchers emphasize this issue, while also acknowledging that the use of AR in education is still in its infancy [4]. Research has found that the most important factor to influence student learning when working with AR, is the fact that content is represented in multiple ways (multimodal ways) closely together, i.e. as sound, visualization and animation. Multiple representations can facilitate students' experience of scientific phenomena otherwise invisible to the human observer. Some phenomena like magnetic fields are difficult to observe directly, other phenomena are unavailable because of their size, such as atoms or galaxies. Time may also be a dimension that limits the observation, e.g. in the case of continental drift or plant growth [5]. Wu et al. [4] condense the following affordances related to AR:

- it presents learning content in 3D perspectives
- it is ubiquitous, collaborative and enables situated learning
- it supports learners' sense of presence, immediacy, and immersion
- it visualises the invisible

- it bridges formal and informal learning

Wu et al. [4] refer to three groups of stakeholders in the development of the use of AR for education: teachers/educators, researchers, and ICT-designers. This is why the project needs to be guided by usefulness for teachers and students in the process of teaching and learning core ideas and practices in science [6]. We claim that the task of *designing technology to promote learning* is best qualified by merging the perspectives of teachers with the perspectives of the other experts groups. This leads to the research questions guiding the research activities in stage 1.

2.1 Research Questions

- In relation to enhancing student learning in science with augmented reality, what affordances are identified by an international panel of experts?
- How can these affordances be condensed in a framework guiding the design of augmented reality for educational use in science education?

3 Methods

The Delphi methodology is a qualitative approach facilitating the systematic identification and analysis of the judgements of individual participants in a panel of experts [7]. Issues are explored through multiple iterations with two or more rounds of sequential questionnaires concerning a specific topic. Condensations of opinions derived from one questionnaire are included in the next. All in all, 35 experts, teachers, science education researchers and ICT designers were identified from the four participating countries. The first questionnaire (Delphi 1) used mainly open-ended questions about ideas for, and reflections about, challenges/pitfalls related to the use of AR in science education. The second questionnaire was designed with mainly closed categories and the participants were asked to rate the importance of various dimensions identified in Delphi 1. A preliminary framework developed based on Delphi 1 was refined based on the findings from Delphi 2. The final framework was tested in the research team in an iterative process of rating the same AR application, comparing ratings and developing the description of the categories.

4 Findings and discussion

50 % of the reflections referred to looking into things, which is otherwise invisible or hard to understand for students. This must be seen as the core of educational AR, describing the overall affordances in relation to student learning. Many of these reflections specifically refer to the possibility of 3D visualization. The possibilities of ‘situated learning’ was mentioned directly or indirectly as examples in 15% of the reflections and 15% mentioned possibilities for interactivity and a creator perspective: “Allowing students to explore rich astronomical measurement-databases, as if they themselves were directing and focusing the telescope and doing the measurement”.

Many of these reflections refer to student inquiries and a data driven perspective. Creating possibility for student collaboration and reference to socio-scientific issues like climate change and renewable energy etc. was also frequently included. Based on the reflections across questions a range of dimensions were identified. These categories could be placed in 11 continua in relation to the educational uses of AR in science education (figure 2).

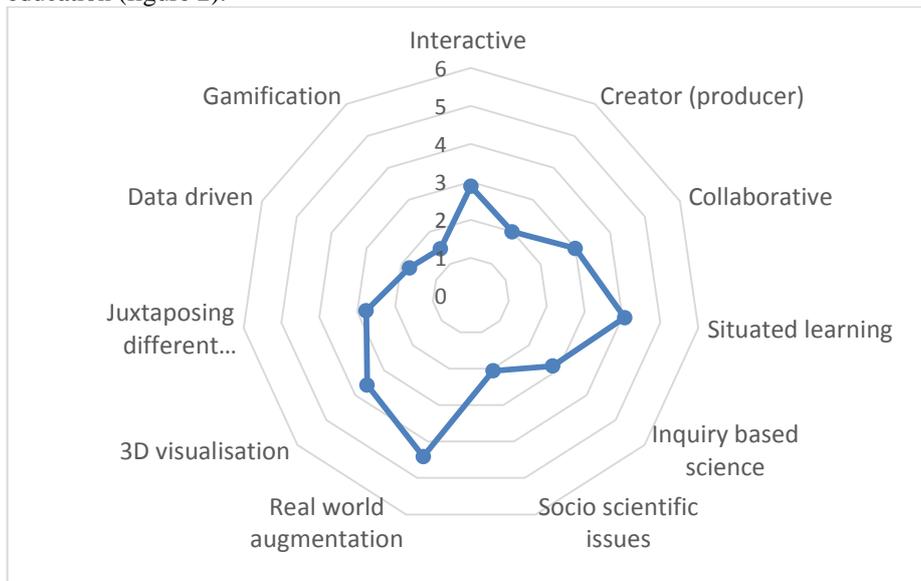


Fig. 2. An example of how a certain AR application can be categorized

The experts also referred to pitfalls like ‘technical barriers and lack of resources in class’ (25%) and 20% referred to ‘truly educational use’: “...an app which is truly educational and addresses a requirement in science”. The frequent lack of interaction when students are working with the currently known AR applications was mentioned by 15%. Based on the preliminary framework developed based on the Delphi 1-survey (figure 2), the experts were asked to rate the 11 dimensions. Based on the ratings in the Delphi 2 – survey, all 11 dimensions appear to be relevant, but the most important dimensions to take into account when designing AR for science education are the interactive, collaborative, inquiry based and creator (producer) dimensions. The final framework, however, is further developed to include only 9 continua based on the dimensions identified by the experts as the most important. The gamification and socio-scientific dimensions (figure 2) are not included in the final framework, but will be exemplified in the user-guide.

Summing up on the findings it is clear that all three expert groups referred to the development of AR technology for education as only being important if explicitly considering how the technology can be used to mediate student learning of relevant science content. This principle of starting from the learning objectives and designing learning technology with a clear sense of what is to be achieved for learners and then

challenging the technology to provide it [8] is widely acknowledged among all the experts. The rich material of concrete examples from the experts can be used in the project to fill in a gap in the research base, pinpointed by Raku et al. (2014), regarding contexts where AR technology might be more effective than other educational mediums. In the AR-sci project, the framework has already supported the choices for design of “show-case” material for stage 1.

5 References

1. AR-sci project webpage, <http://www.ar-sci.dk/>
2. Azuma, R., Baillot, Y., Behringer, R., Feiner, S., Julier, S., & MacIntyre, B.: Recent advances in augmented reality. *Computer Graphics and Applications, IEEE*, 21(6), 34–47 (2001)
3. Cheng, K.-H., & Tsai, C.-C.: Affordances of Augmented Reality in Science Learning: Suggestions for Future Research. *Journal of Science Education and Technology*, 22(4), 449–462 (2013)
4. Wu, H., Lee, S.W., Chang, H. & Liang, J.: Current status, opportunities and challenges of augmented reality in education. *Computers & Education*, 62, 41-49
5. Radu, I. (2014). Augmented reality in education: a meta-review and cross-media . analysis. *Personal and Ubiquitous Computing*, 18(6), 1533–1543 (2013)
6. Krajcik, J.S. & Mun, K.: Promises and challenges of using learning technology to promote student learning of science. N. Lederman & S. Abell (eds.) *Handbook of Research in Science Education*, Vol II, p. 337-360 (2014)
7. Osborne, J., Collins, S., Ratcliffe, M., Millar, R. & Duschl, R.: What “ideas-about-science” should be taught in school science? A Delphi-study of the expert community. *Journal of research in Science Education*, 40(7), 692-720 (2003)
8. Laurillard, D.: Rethinking the teaching of science. In R. Holliman and E. Scanlon (eds.). *Mediating science learning through information and communications technology*, pp 27-50. Oxon: Routledge (2004)