THE IPEAR APPROACH: COMBINING PEER LEARNING AND AUGMENTED REALITY IN EDUCATION

Chryssa THEMELI
Ruth MALOSZEK
Friedrich-Alexander-Universität Erlangen-Nürnberg, DE

Carme ROYO
eucen, BE

Email: ruth.maloszek@fau.de

Keywords: *Peer learning, visual learning, augmented reality, inclusive learning, case studies*

ABSTRACT

The European Strategic Partnership iPEAR[1] has explored the opportunities that arise for education when motivating and engaging students by combining the pedagogy of peer learning with the visual technology of Augmented Reality (iPEAR approach). iPEAR case studies seek to prove the efficacy of this approach that can be applied in all fields of education, from primary school to higher education and continuing education. Cases have been collected from the most diverse subject areas, illustrating widespread applicability of the iPEAR approach.

INTRODUCTION

The technology of Augmented Reality (AR) is quite commonly used in subjects like surgery, architecture, engineering and in the gaming industry. In other subject areas, however, this technology is barely used. In Europe-wide case studies (universities and higher educational institutions from Greece, Norway and Germany have taken part in this study. These institutions were part of the European Strategic Partnership iPEAR), proof was sought for AR's use in educational settings of any kind, i.e., in creative and philosophical subjects as well as in social science, in formal as well as in informal learning and supporting university lifelong learning and (ULLL) and university continuing education (UCE). In order to facilitate the accessibility of AR for a range of educators, some segments of these case studies worked with easily accessible mobile AR tools and WebAR.

The existing research focusses either on the phenomenon of peer learning or the supporting character of AR, mostly on individual learning results. High-end AR is perceived even more so as a means for individual learning (only a minority of studies deals with AR as a means of collaborative working and these studies concentrate on STEM (Affendy 2019)). This perception has been slowly changing, however. Recent studies show that the technology of AR is more inclusive when used in collaborative learning settings, meaning that all kinds of

[1] iPEAR is the acronym for "Inclusive Peer Learning with Augmented Reality" and stands for a European Strategic Partnership that was co-funded by the European Commission in 2020-2023 (2020-1-DE01-KA203-005733).

learners can successfully take part in the learning.[2] Our study adds to this change of perception. It combines AR with the pedagogy of peer learning – what we call the iPEAR approach. It shows that AR can serve collaborative learning.

CONTEXT

The iPEAR approach is a pedagogy based on visual learning with peers, used extensively in continuing education and lifelong learning (LLL) environments. Peer-to-peer (P2P) instructions originated with Eric Mazur (Mazur, 1997) when he proved that students are more motivated and engaged when they learn with their classmates and consequently learn better. Moreover, their perception of the course positively changes and enhances awareness about learning outcomes. Another study (Zhang, Ding, and Mazur, 2017) analysed pre-post matched gains in the epistemological views of science students taking the introductory physics course at Beijing Normal University (BNU) in China. The study also looked at gender differences in student learning attitudes. Gender results revealed that female science majors in the PI classes achieved a more remarkable positive shift in attitudes and beliefs after instruction than male students.

Peer instruction is a much needed and yet not sufficiently widespread pedagogy when it comes to the needs of modern university instruction. It focusses on the social dimension of higher learning and active citizenship, and it is suitable to the inclusion of marginalized groups of adult learners (Royo *et al.,* 2021). Peer learning encourages sharing human experiences and knowledge between students, puts the students' knowledge at the centre of the discussion and values their contribution, and students feel more receptive to real cases and information when it comes from peers. This approach is therefore very relevant in UCE, where contribution from experienced individuals is a key factor to enriching the work done in the classroom. This effect is even more pronounced when combined with visual ways of teaching.

In the context of our study, AR serves as a means of visual learning. The art of visual teaching describes the nonlinear, tangential ways our thinking moves (Sousanis, 2015). The iPEAR pedagogy considers three critical variables: the philosophy of Heutagogy (Self-direction and self-efficacy), inclusive praxis as democratic participation in LLL, social learning theories (P2P approach), visual media literacy and the artistic element of developing an instructional design that addresses the technology-enhanced learning perspective (Figure 1).

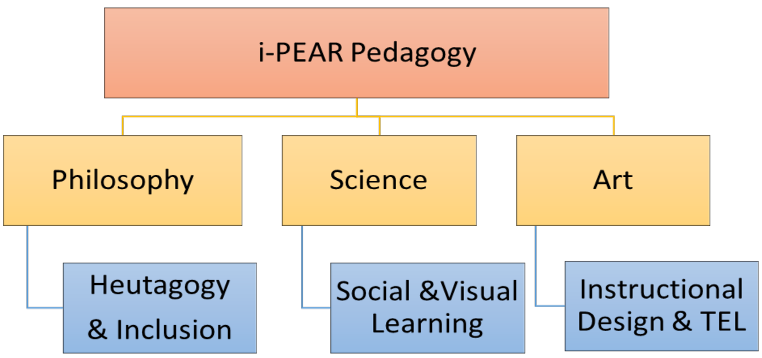

Figure 1: General categories of the iPEAR pedagogy

[2] Recent studies from Harvard add evidence to this. See Radu 2023 and further works cited under https://pubmed.ncbi.nlm.nih.gov/35500084/

iPEAR CASE STUDIES

To prepare educators for their role in the iPEAR case studies[3], they were thoroughly briefed by the iPEAR consortium. They were equipped with the iPEAR toolkit (Terzopoulos,2023) introducing them to AR mobile applications suitable for educational purposes. They were also briefed to use AR in a peer learning setting. All other parameters were up to them:

- the learning situation (seminar or other)
- the technical equipment needed to realize the concept
- BYOD or not
- how many students taking part
- offer an AR experience to students, or let students prepare an AR experience as a meaningful part of the course
- how to prepare the students for the task
- how to lead students through the task

Some cases were performed with HoloLens, a head mounted device, whereas most educators made use of mobile applications. The tools used in the cases are introduced in the iPEAR Toolkit.

	Subject	Case / method	Didactic goal	AR Tool
1	Christian archaeology	Treasure hunt with ready-made AR	Gain knowledge on monuments	Sketchfab AR
2	Media science	Students develop AR experience	Create a practical e-learning module	Metaverse
3	Education	Explore AR tools and present experience	Develop skills in technology enhanced teaching	ARTutor4
4	Sports	Use AR training app	Train basketball techniques	HomeCourt
5	Physiology	Use AR app	Get information on the structure of rat brain	Nevrolens for HoloLens2
6	Animation and interactive media	Students develop AR experience	Create AR animation for elementary school kids	JigSpace
7	Animation and interactive media	Teacher develops augmented clickable buttons	Trigger discussion on ecological issues	V-Director
8	Fine arts and new media	Students develop AR experience	produce interactive AR installation for spectator to interact and affect the installation using the forces of nature (gravity, wind, etc.)	UniteAR
9	Graphic design	Students develop AR experience	Tell a mixed reality story for a short product advertisement	3dBear Vidinoti AR
10	Graphic design	Teacher develops augmented QR codes	Incorporate information on the new course project and how to conduct it	3dBear Vidinoti AR

Table 1: List of cases and subjects realised in iPEAR 2021-2022[4]

[3] iPEAR Cases were collected between April 2021 and July 2022.

[4] For more details on the single cases see Maloszek 2023 and Themeli 2023. Apart from the ten cases presented in table 1, another 11 cases were produced that are not documented here as educators did not take part in the systematic analysis, but their students nonetheless answered the survey questions.

At the end of the semester, educators took part in a semi-structured interview about the setting of their case study, its content, the approach they chose and the outcomes. Students were asked to answer some questions in an online survey. As a result, half of the educators (apart from the HMD case) let students bring their own device (BYOD). Some chose to present AR that students had to make use of. Others chose to let students prepare their own AR experience (see table 1).

ANALYSIS OF CASE STUDIES

The overarching research question for the analysis of the iPEAR case studies was a pedagogical one: Does the iPEAR approach improve students' (and continuing education learners in particular) motivation, engagement and autonomy and how? This study does not focus on the question of whether educators feel prepared for this kind of teaching, although this question is an important part of the picture when thinking about ULLL and UCE. Therefore, the results of the iPEAR project might be useful for educators throughout Europe, enabling them to take steps for their own further professional learning. To find out about the improvement of learners' motivation, engagement, and autonomy thanks to the iPEAR approach, the educators' and students' answers were analysed in a mixed methods approach (Creswell, 2009), sampling the interviews from the 21 higher education educators from Greece, Germany and Norway that participated in the case studies, and of their students who responded to the online survey.

In their responses, educators explored students' motivation, engagement, and autonomy in working with their peers (with or without the intervention of an educator). More categories emerged from the data, including inclusion, creativity, group dynamics and visualisation. Finally, they were asked to comment on how the iPEAR instructional design could be improved or used more effectively.

Overall, the educators' feedback on iPEAR was positive and served the learning objectives. Informants claimed that AR-selected tools provided the students with new ways of creating and interacting with the natural world and experiences that would not be possible in a completely real or virtual world. While AR, as a creativity channel, promoted explorative learning and problem-solving, creativity was considered a form of literacy in the iPEAR experiment. An educator of graphic design (9) concludes: "After the procedure, [students] felt like explorers, who are part of the same expedition. […] AR apps helped students understand new creative paths." An educator in the field of fine arts (6) commented: "[…] the AR experience helped students understand the main topic in a creative way and express their thoughts at the end (peer learning)."

Educators maintained that the iPEAR design functioned as a motivational force because of the social interaction, excitement of working with innovative tools, social responsibility for learning and visual and immediate feedback as a rewarding process. Students liked working with their friends and classmates more than listening to a lecture in class or online, tried harder and were proud of their visual content. Depending on the composition of the group, the peer-to-peer relationship was sometimes more democratic, while in another case, a mentor led the teamwork. The decision about roles was based on the group dynamics and the students' personalities, and the responsibilities could be adjusted over time.

Of course, the most creative instructional design of the activity reinforces the rewards for students. Rewards could be grades, the assessment of the task by peers (respect from peers), or the enjoyment of producing visual content with classmates and building digital skills with innovative tools such as AR. As the educator of archaeology (1) noted: "As soon as you do group work, you're the heroine. Therefore, there has always been a great commitment, if they were able to do something together. And the AR tools promote that, I think, because it always has something playful and something futuristic." Even underperforming students were engaged and worked collaboratively. Mutual learning was a catalyst for integrating students without mobile phones and without much sophistication in new technologies. The guidance from fellow students helped them to participate and learn.

Teachers claimed that the students broadened their visual language boundaries through peer learning and new technologies. As an informant of graphic design (10) put it: "The team is happy with the learning results, as […] the learning experience was like a treasure hunt game." The educator using HMD in the field of physiology (5) uttered: "It was very apparent that the students were very enthusiastic at the end; they said that this was a great way of teaching; it was very interactive and allowed them to actively explore and discuss among them."

When technical issues like weak Wi-Fi coverage, compatibility issues, or lack of mobile devices, hindered students' performance, there was a potential reluctance to share and experiment. Some educators managed to solve these issues creatively with inclusive praxis. They urged their students to share devices, ideas and roles within the peer groups so that all members could contribute. Generally, educators claimed that AR tools must improve to avoid battery or data overuse, be user-friendly, create more 3D models (images and domain-specific resources, programming courses, music etc.) and provide more possibilities for collaboration.

The student respondents were graduate and undergraduate students from various national backgrounds and disciplines. The convenience sample included students from Germany, Norway and Greece from medicine, archaeology, graphic design and media studies, to name a few (other subjects represented in the study were sport science, education, photography and fine arts). The survey included 16 informants from Germany, 17 from Norway, and 181 from Greece (214 in total).

Students were asked to answer four questions on a Likert scale 1-5 (strongly agree – strongly disagree). These questions, designed to be evaluated quantitatively, were each supplemented by an open Why-question that delivered additional qualitative information on students' impressions and thoughts.

1) Did you like the peer learning approach (working with and teaching your classmates)? Why?

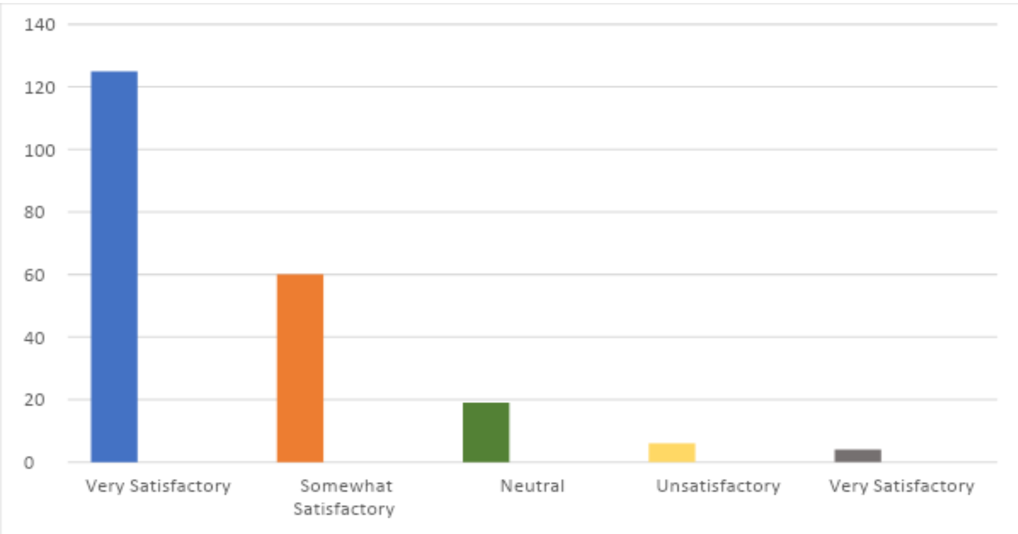

Figure 2: Students' responses to question 1 on Likert scale 1-5 in total.

The distribution of answers to question 1 shows that most students appreciated the iPEAR perspective of learning while teaching one another (185/214). Only a minority was neutral or found it unsatisfactory or very unsatisfactory (19/10). The illustrated answer to 'Why?' positively commented that the method was engaging, motivational, creative and innovative, teaching them new digital and cooperation skills. On the negative side, technical issues such as compatibility, digital divide, and internet connection affected the efficiency of the iPEAR task. Along the same lines, cognitive overload (tiredness and headaches, poor collaboration, hesitation in trying new technology and educators' preparedness) affected the learning outcome of the peer-learning with AR tools.

2) Were you more interested in teaching each other and sharing content with your peers and AR tools? Why?

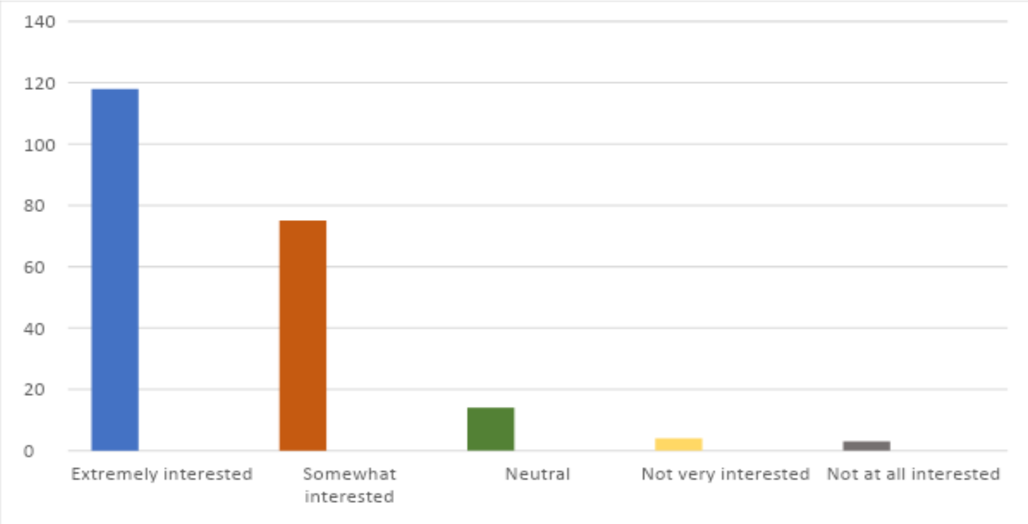

Figure 3: Students' responses to question 2 on Likert scale 1-5 in total.

The answers to question 2 show that all in all, a great majority (183 out of 214 participants) were 'interested or very interested' in the project and only a minority of 17/7 students were neutral/uninterested. The positive comments concentrated on the innovative use of tools for learning, the quality of collaboration in class and online, and the AR technologies' visual elements. The iPEAR task helped them learn together in a fun, game-like and creative way that triggered enthusiasm, motivation and personal responsibility for learning with peers. The few negative comments focussed on technological issues, such as technology's role in the task and the availability of devices. One student felt anxious when trying out new technologies.

3) Did this learning approach make you feel more responsible for your learning? Why?

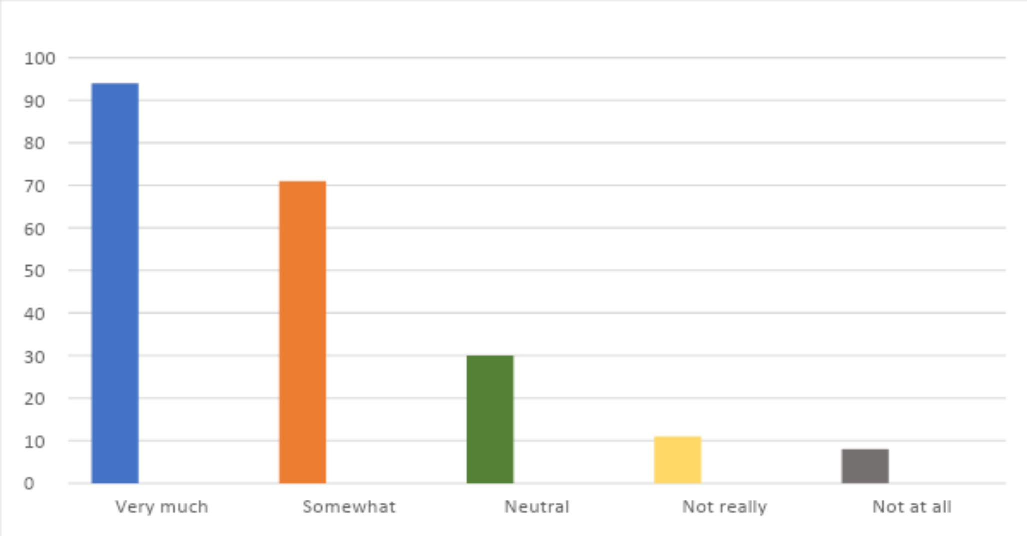

Figure 4: Students' responses to question 3 on Likert scale 1-5 in total.

Despite the different tools and disciplines, the responses regarding empowerment were overall positive (165/214). Only a minority of students was neutral or negative (30/19). The students who did not feel empowered considered the iPEAR learning childish and preferred a more teacher-centred approach rather than taking the responsibility of knowledge sharing with others. On the positive spectrum, research informants were excited that they were allowed to improvise with the tools, brainstorm with ideas, and work with others. They felt responsible for the learning outcome of the iPEAR task, such that even the 'bad' students participated more.

4) Do you think it would be helpful in other courses as well? Why?

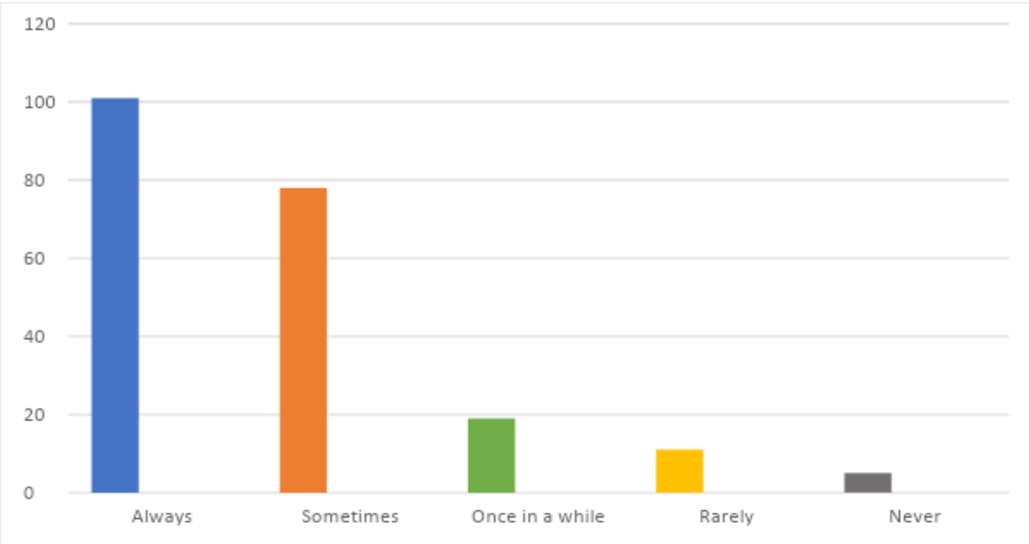

Figure 5: Students' responses to question 4 on Likert scale 1-5 in total.

Almost half of the students (101/214) think that the iPEAR approach has the potential to always be applied in courses; 78 claim that it could be used sometimes, 19 once in a while, 11 rarely and 5 never. On a positive note, students utter that visuals make learning more experiential and better explain abstract concepts. Digital skills are essential and social interactivity makes learning fun and more engaging. The negative comments focus on the misconception that AR is for children, the reluctance to work and learn with others, and the lack of incentives. The statement that visuals are tiring refers mainly to HoloLens headsets. Technologies are challenging, especially for inexperienced students; some see barriers to using iPEAR in disciplines such as maths.

These results of the student survey prove the positive impact of the iPEAR approach independently of the subject and verify the expressions of educators. The majority of students liked the experience of learning with peers; they were interested in teaching each other and in sharing content and thoughts, as the collaborative approach combined with the visual technology of AR motivated them and made them feel responsible for their learning and for the group. Some reported feeling enthusiastic by this opportunity to learn together in a game-like and creative way. Part of this enthusiasm is surely owed to the novelty of the iPEAR experience, but this cannot diminish the result of the students’ survey significantly.

CONCLUSIONS

The evaluation of students’ answers based on the frequency of responses-inferential statistics confirm the hypothesis that the iPEAR approach is a practical learning method. Proof is supplied here through a sample of university students, but the approach could be extended in the future for groups of UCE learners. In our understanding, all learners at the university level react similarly to the specifics of the iPEAR approach.

As a generic pilot study that aims to map technology-enhanced pedagogical interventions, there is evidence that the iPEAR approach could enhance students' interest, motivation, and empowerment in a broad spectrum of courses. Despite the various tools and disciplinary boundaries, the students’ perspective on the iPEAR approach is cumulatively positive. They felt engaged, motivated and empowered to work creatively with their 'learning buddies' to explore AR, visuals, and human-to-human relationships. The pedagogical model promotes gameplay, visualisation, wonder and discovery learning instead of uniform lecture time. They could apply AR digital skills and cooperation experience in their future careers.

The preparation of students by their educator was crucial for them to understand what they had to do. A lack of training, vague assignments, or too many tools to choose from could easily end up in mutual frustration. Planning in terms of engagement, time and reflection process have substantial impact on students' performance. Depending on their students’ learning disposition, educators could be a *queen on a throne*, letting students work collaboratively and observe; in other cases, they could be *guides on the side*, mentoring P2P groups or *fellow travellers* learning at the exact times as the students.

A prerequisite of the successful application of the iPEAR approach is that educators embrace inclusive values (no-one left behind perspective) to avoid marginalising students with individual difficulties, compatibility issues, lack of pieces of equipment, etc.

The limitations of the iPEAR approach lie first and foremost in the digital divide that may create havoc for educators and their students. Some devices, such as HoloLens, are expensive to be bought by institutions. The lack of devices in class and limited internet connection could hinder the use of the AR aspect. The BYOD perspective causes difficulties due to socioeconomic status. Some students have elaborate smartphones that support AR technologies, while others may not be able to afford to buy such devices. Compatibility issues arise with some devices, for instance, between Apple and Android devices, and older devices still do not support ARCore. Creative solutions, sharing of devices, and collaborative netiquette could solve some of the challenges of the iPEAR approach. Additionally, a reward system for inclusiveness and peer-to-peer learning helps motivate students to engage more and mirror positive behaviour for democratic participation in education.

In the future, new apps and tools will be developed that mix the physical and digital world harmoniously, making implementing the iPEAR pedagogy even easier. Further research could shed more light on how visual learning could enhance understanding, memorisation, and creativity. Pedagogies promoting students' choice and empowerment are future directions that could lead students to be self-directed, lifelong learners.

REFERENCES

Affendy, N.M.N. and Wanis, I.A. (2019) '*A Review on Collaborative Learning Environment across Virtual and Augmented Reality Technology*', *OP Conference Series Materials Science and Engineering,* 551(1):012050. https://doi.org/10.1088/1757-899X/551/1/012050

Creswell, J.W. (2009) '*Research Design: Qualitative, Quantitative, and Mixed Approaches*'. Thousand Oaks, CA: Sage.

Maloszek, R. (2023) '*The Humanities – Case Studies at FAU*', *iPEAR conference proceedings*. Available at: https://i-pear.eu/resources/

Mazur E. (1997) '*Peer Instruction: A User's Manual Series in Educational Innovation*'. Prentice Hall, Upper Saddle River, NJ.

Radu I, Schneider B. (2023) '*How Augmented Reality (AR) Can Help and Hinder Collaborative Learning: A Study of AR in Electromagnetism Education*', IEEE Trans Vis Comput Graph. 2023 Sep;29(9):3734-3745. Doi: https://10.1109/TVCG.2022.3169980

Royo, Carme; Cendon, Eva; Németh, Balázs; Hiebner, Sjelle on behalf of the Steering Committee of eucen (2021) '*Equipping Higher Education Institutions for the Future – The Role of University Lifelong Learning*'. eucen Position Paper, issue 4. Published in 2021 by eucen. https://eucen.eu/policy/position-papers/

Sousanis, N. (2015) '*Unflattening*'. Cambridge, MA: Harvard University Press.

Terzopoulos, G. (2023) '*Evaluation of Educational AR Apps and Toolkit with Unified Guidelines for Educators'*. Available at: https://i-pear.eu/resources/

Themeli, C. (2023) '*Inclusive Peer Learning and Augmented Reality in Higher Education. Technology-enhanced (TEL) learning perspective*'. Available at: https://pressbooks.pub/ipear/

Zhang P., Ding L. and Mazur E. (2017) '*Peer Instruction in Introductory Physics: A Method to Bring About Positive Changes in Students' Attitudes and Beliefs*', *Physical Review Physics Education Research*, 113, 010104, pp. 1–9. Available at: https://mazur.harvard.edu/files/mazur/files/rep_772.pdf