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Inclusive Peer Learning Pedagogy with Augmented Reality–iPEAR

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Inclusive Peer Learning Pedagogy with Augmented Reality– iPEAR

Abstract

The paper aims to show a pedagogical design focusing on peer learning and augmented reality to improve students' engagement, motivation, and empowerment. During the pandemic, strong research evidence suggested that collaborative and inclusive approaches such as peer learning simultaneously enhance mental health, student satisfaction and learning outcomes. Augmented reality unveils the positive effects of visual learning, which could be used creatively to stimulate interest, creativity, and participation. Thus, the pedagogy is philosophically framed within social learning and self-efficacy theories. Inclusion is defined as the social value of sharing information, devices and ideas and as instructional design that respects the learners' needs and preferences. The research findings led to the four pillars of the theoretical model. The pillars are AR tools, Peer-to-Peer task design, visuals, and peer feedback culture. The generic pedagogical framework was examined from 2021 to 2022 as part of the intellectual outputs of a European Erasmus project in a higher education project called i-pear.eu, creating a compendium of good praxis.

Keywords

Augmented reality, peer learning, pedagogy, technology-enhanced learning, visual literacies

Cover Page Footnote

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INCLUSIVE PEER LEARNING PEDAGOGY WITH AUGMENTED REALITY– IPEAR

"The first challenge for education is to think how to even describe the more abstract contours of the present in a way that is neither old wine in new bottles nor new wine in old bottles."

(Jandrić, 2017, p. 115).

Introduction

Authoring a paper on pedagogy as a theoretical framework is challenging because educators, instructional designers, and researchers need help grasping philosophical approaches. Pedagogy is a fearful term for researchers, educators and learning technologists (Goodyear, 2019), with complicated social-political impacts (Freire, 2017). Furthermore, Themelis (2022), the initiator of the iPEAR project, recommends that educators reflect on their pedagogy as philosophy, science, and artistic repertoire for lifelong learning. The ultimate learning outcome of the pedagogy in ancient Greece was leading the students to self-efficacy and self-direction for well-being and intellectual growth- to adulthood. The pandemic created chaos in many educational institutions. Educators needed clarification about using so many new tools on such short notice, and students felt isolated in a two-meter society. Drop-out rates skyrocketed worldwide, and some students never returned to schools or Universities (UNESCO,2020).

We experienced long-lasting lockdowns (Christakis, 2020) and social isolation during the pandemic that challenged our mental and physical health. Consequently, teaching and learning performances declined. More than ever, educators realised the impact of feelings on learning. Research shows that positive feeling enhances performance and memorisation (Langer, 1997; Osika et al., 2022), but the two-meter society (the distance allowed between two human being during the covid-19 pandemic) has strongly affected people's mental well-being globally. Safeguarding the way people feel is a 'message [that] points towards inserting instinct and emotion into our philosophies and sciences' (Jandrić, 2020c, p.27) and education. The toll of social isolation was evident in many research studies, such as Christakis, 2020, at all levels of education.

Kuhfeld, Soland, and Lewis. (2022) described the disruption to K-12 schooling as seismic and ongoing. Using test scores from 5.4 million U.S. students in grades 3-8, they recorded a significant performance decline in maths and reading comprehension, more substantial than other recent disruptions caused by natural phenomena. In developing countries, UNESCO made

conscious efforts to keep students in schools, especially girls, with two initiatives: learning never stops and supporting girls in the picture. Unfortunately, millions of students could not access schools and universities during the pandemic and quit schools and universities after it. To make matters worse, violence towards girls and women increased unprecedentedly. Boys' disengagement from schools was also evident, especially in countries where poverty rose, and the boys had to work to survive (UNESCO, 2020).

During the lockdowns, the peer-to-peer (P2P) approach – as an antidote to isolation – provided a supportive alternative to monotonous and alienated distance courses based on lectures (Vergroesen, 2020). Students could co-create content, share personal experiences, and analyse, evaluate, and retain knowledge while working with peers. Peers were also an antidote against the passive learning approach (online lecturing) and loneliness of the two-meter society. Studies (Cohen, Kulik, Kulik, 1982; Freeman, Eddy, McDonough, Smith, Okoroafor, Jordt, & Wenderoth, 2014) proved that students would have more chances to pass the class and deepen their understanding of the subject matter if they were working with others. Student-led seminars, peer reviews, and discussion topics in breakout sessions are peer-to-peer active learning approaches that have become popular in remote teaching.

Scientists have shown that 'learning friends' – peer learning – makes a difference (Themelis, 2022; Boud, Cohen & Sampson, 2014; Keenan, 2014; O'Donnell & King, 2014; Riese, Samara, & Lillejord, 2012). Students and educators, especially in the remote emergency setting, have chosen the inclusive visual language of the internet using all forms of visuals: emoji, videos, 3D animation, QR codes, and augmented reality whenever possible. Visual reading and thinking are inclusive for two reasons: it assists students facing learning challenges (Sime & Themelis, 2021); and convey meaning by providing a concise and memorable micro-learning experience.

The illumination of the pandemic was to refocus learning through relations and place the human (educator and students) as the core element in the educational design (Themelis, 2022). At the same time, peers are considered an asset for eLearning. Remoteness made us more sensitive and accommodating to the human condition of our students. We – educators – have entered their houses, sometimes met their siblings or pets, and provided a space for communicating our intense feelings of isolation and insecurities. On the other side, we, the subject matter experts, showed a more vulnerable, humane side as we exposed our lack of digital skills and often asked for student'' technical assistance. Consequently, education will not be the same, but it may become more human (Levander & Decherney, 2020).

To address some of these challenges, the Erasmus + iPEAR project was initiated: Inclusive Peer Learning with Augmented Reality Apps (grant number 2020-1-DE01-KA203-005733). The project investigates whether peer learning and AR tools could enhance student'' motivation, engagement, and empowerment. The generic pedagogical framework developed as a part of this project was examined from 2021 to 2022 by interviewing n = 22 European educators and surveying n = 214 students (research informants).

Theoretical framework

Philosophically speaking, education could be considered a path to self-efficacy via social learning theories. The iPEAR framework is based on the work of the psychologist Albert Bandura (1971 & 1977). Students must be lifelong learners to address the demand of the job market and search for personal fulfilment via a learning process to unlearn old patterns of thinking and obsolete digital skills and replace them with new competencies, attitudes, and roles- while maintaining well-being. Albert Bandura (1977) argues that learning is not an isolated act, but we can learn by interacting with others. Social learning theory, originated by Albert Bandura, proposed that learning occurs through observation, imitation, and modelling and is affected by factors such as attention, motivation, attitudes, and emotions. The theory embraces the interaction of environmental and cognitive elements that affect peopl''s learning. Bandur''s social learning theory explains that learning can also occur simply by observing the actions of others.

In the same train of thought, Ahn, Hu and Vega (2020) claim that social-cognitive processes involved in role modelling tend to be ignored. Their work provides an overview of role model research in education, detailing researcher'' focus and emphasis on identifying aspects of role model effectiveness. They focus on role model'' attentional, cognitive, and motivational processes and ask for more research on imitation in education.

Peer-Learning, augmented reality and inclusion

Before presenting the pedagogy, it is vital to illustrate the terms peer learning, Augmented reality, and inclusive praxis. The three ingredients of the pedagogy aim to address the need to work with others as a social protection mechanism, learn faster with visuals and promote student'' agency (if students create the visuals) in a class environment where inclusion is interpreted as the perspective to respect individual or socio-economic needs. iPEAR research informants have estimated that the pedagogy has the potential to enhance engagement motivation, creativity and, in some cases, empowerment.

There are many approaches to peer learning, including different roles and responsibilities. Boud, Cohen, and Sampson define it as“"the use of teaching and learning strategies in which students learn with and from each other without

the immediate intervention of a teacher (1999, p. 413). This definition is generic because the educator could decide how much assistance the students need to reach the learning outcome (student'' level of autonomy or digital skills to use AR). It is also a form of reciprocal peer learning. Wessel (2015, p.14) says that when students engage in P2P tasks, they can learn practical skills such as critical feedback and thus teach more effectively. Palmer and Blake (2018) note at the Harvard Business Review that peer-to-peer learning fits naturally with how we naturally acquire new skills with the *Learning Loop*:

> People gain new skills best in any situation that includes all four stages of what we call the "Learning Loop": gain knowledge; practice by applying that knowledge; get feedback and reflect on what has been learned. Peer-to-peer learning encompasses all of these (para.5).

Augmented Reality (AR) connects, with the help of technology, visual information (artificial world) to the real world. Its technical means include multimedia, 3D modelling, real-time tracking and registration, intelligent interaction, sensing, and more. Its principle is to complement or *augment* computer-generated virtual information, such as text, images, 3D models, music, video, etc., to the real world (Hu Tianyu et al., 2017). AR tools might be single-user or collaborative and have different affordances depending on the technology used and on the collaboration mode supported (remote or co-located).

AR technologies can be divided into several categories. In the iPEAR project, we focus on the following three: Mobile apps are a common way to experience AR through a mobile device (phone or tablet). The user opens up the device camera and sees the real world with digital augmentations added to it (e.g., by recognising a marker/QR code or the phone's location). The quality of the experience heavily relies on the quality of the camera, the quality of the visuals and the device's processing power. WebAR lets users view the AR experience using their browser (laptop or mobile device). WebAR experiences are available for laptops through the webcam. AR Head Mounted Displays (HMDs), designed by, e.g., Microsoft, Magic leap and Apple, allow the users to access immersive, high-quality AR content, often with natural interfaces (such as using hand gestures for input) (iPEAR resources, 2023).

Research (Alrashidi et al., 2017; Loup-Escande et al., 2017) found that AR could offer effective real-time feedback. Alrashidi et al. (2017) tested an AR system compared to a paper-based manual during coding activities in computer science. The AR group experienced a lower cognitive load and improved grades than the control courses. This happens because if the information is presented as videos, diagrams, images, 3D models, etc., it is

easier to be remembered. Students are used to consuming videos or any visual form in their digital engagement with social media and the internet (Lacković, 2021). Mystakidis, Christopoulos, & Pellas (2022) reviewed the literature on STEAM and found significant positive influences on learning and students' motivation, while Nesenbergs et al. (2021) find that the advantages are evident in distance courses as well.

The collaborative aspects of AR are worth exploring more in the future. Most iPEAR research informants used mobile AR tools in class or lab, having real-time interaction in the same space (co-located). Of the 22-iPEAR case studies, only one deployed Hololens (AR Head Mounted Display), and AR mobile apps connecting people in different locations and working on the same anatomical models, such as the Nevrolens described below. Ens et al. (2019) reviewed the literature on collaboration through mixed reality and identified the following dimensions that must be considered:

- Time and space - synchronous or asynchronous interactions and co-located or remote collaborations.
- Symmetry - equal roles and skills or different roles and skills..
- Artificiality - the description of space as physical, digital, or hybrid.
- Focus - describes the primary target of collaborative activity - environment, workspace, person and object.
- Scenario - the summary of all the above elements and the sharing culture of workspace, experience, feedback, and telepresence.

While a detailed discussion of these dimensions and their implications for peer learning with AR is outside the scope of this paper, this overview emphasises the complexity of the topic and identifies directions for future work.

Collaboration (P2P with AR tools) is the heart of the iPEAR approach, but it should be shared and inclusive to work effectively. Inclusion is a crucial concept for the project. United Nations working with all the members, created the vision of 17 sustainable goals for every field of life that aim to achieve by 2030. The United Nations' Goal 4: Quality education emphasises inclusive and equitable education, defining it as

> . . . a process of systemic reform embodying changes and modifications in content, teaching methods, approaches, structures and strategies in education to overcome barriers with a vision serving to provide all students of the relevant age range with an equitable and participatory learning experience and environment that best corresponds to their requirements and preferences. (United Nations, General Comment No. 4, 2016, p.4)

The iPEAR pedagogy provides options for students according to their needs and preferences in a sharing peer-learning vulture using innovative AR tools.

iPEAR pedagogy

The iPEAR pedagogy is based on the philosophy of self-efficacy (heutagogy as self-determined learning), the science of social learning and the artistic teaching repertoire of designing peer learning tasks – scenarios using visual via AR tools. The teaching repertoire is enriched with a peer-feedback culture that rewards sharing via inclusive ethics and praxis.

Students' level of autonomy and e-maturity (digital skills)

The first step for educators before adapting the iPEAR model is to identify the students' level of autonomy. For instance, undergraduates and postgraduates have different skills and needs for self-directed learning, and a survey or student discussion could help educators determine their preferences and needs. In many cases, though, it is not feasible to analyse the target audience's level of autonomy, which is why students need more options to choose from within courses. This is the definition of inclusiveness illustrated above by the UN and adopted by the iPEAR pedagogy.

To further explain, the science of pedagogy targets discovering the level of independence and digital skills before designing learning objectives to design more choices for learning. For instance, learners from different cultural backgrounds may be accustomed to teacher-centred approaches. The so-called 'Sage on the stage' is responsible for all the choices of assignments and lectures to target learning goals. This target group may not be well-prepared for eLearning or collaborative praxis.

Conversely, educators could be described as facilitators- the 'Guide on your side' or fellow travellers for postgraduate or PhD candidates. Thus, the educator's roles change according to the target group's characteristics: children or adults, cultural factors, and previous experiences. It is important to note that educators could show their students emancipatory and inclusive approaches, step by step, with rewarding inclusivity and social interaction.

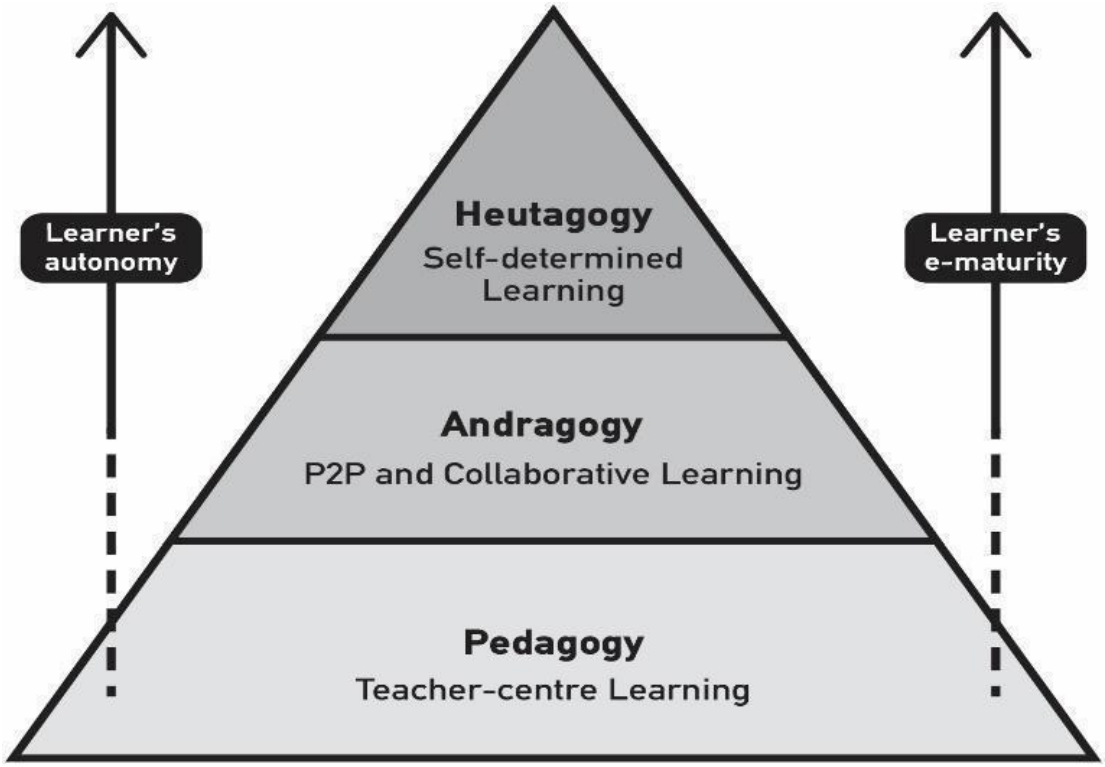

Fig 1. iPEAR Pedagogy

The process of self-efficacy as students' competency to learn alone and with others (learner's autonomy) and use digital tools (e-maturity). The baseline is the learning objectives within the disciplinary boundaries. The incremental levels show the transition from pedagogy to andragogy, then to heutagogy as self-efficacy and awareness (based on Canning, 2010, p. 63). (Themeli, 2022). Image edited by Eleni Tsampra.

The final destination is heutagogy. Students need time and support to reach the top level. It depends on the educator's priorities to show the importance of inclusiveness and collaboration even when students need a teacher centre approach. McAuliffe, Hargreaves, Winter and Chadwick (2008) recommend:

- Knowing how to learn and unlearn is essential
- Educators emphasise the learning process rather than content
- Learning goes beyond specific discipline
- Learning goes through self-chosen and self-directive action

P2P is an intermediate level that assists students in enhancing their critical thinking and collaboration skills, moving away from teacher-led activities. The educators could consider their target audience level regarding learner autonomy and e-maturity to use digital tools such as AR and disciplinary priorities and boundaries. Sometimes the educators may choose to use a combination for different pedagogical levels. For example, they could adopt a more teacher-centred approach illustrating the use of the AR and then orchestrating a collaborative P2P assignment for implementing the iPEAR pedagogy to serve learning outcomes. Inclusive values must be explicitly stated and rewarded while sharing feedback, devices, and work equally. In praxis, inclusiveness means that students can share devices, teach each other, resolve conflicts democratically and get rewarded by their peer assessments and educators' criteria.

The framework of iPEAR was designed as an experimental approach that was tested and elaborated in the co-funded Erasmus KA2 project in higher education. The initiative aims to join social learning through peer-to-peer task designs **(**Mazur, 1997) and visualisation as a form of microlearning widely used in vocational training and marketing via AR tools. The AR tools used were free versions of mobile apps, except for a case study from the IMTEL lab in Norway that uses Microsoft HoloLens. During the research process, two more elements were derived from the surveys with students, the interviews with educators, and the literature in the field. They need to understand better the roles (social and ethical) of visuals or visual content creation in learning (visual literacies and media) and gradually build a peer feedback culture (critical thinking). This peer feedback perspective is based on students; previous experiences and cultural background, but it could be reinforced with rewards or incentives initiated by educators. This sharing attitude could make courses more inclusive and help students take more responsibility for their studies and the growth of the learning community. The pedagogy is formulated within the boundaries of informed grounded theory that combines research analysis with updated literature reviews (Themelis, Sime and Thornberg, 2022). The approaches based on Informed grounded theory are in a never-ending evolution as it needs frequent revisions by the literature and new studies.

The iPEAR schema

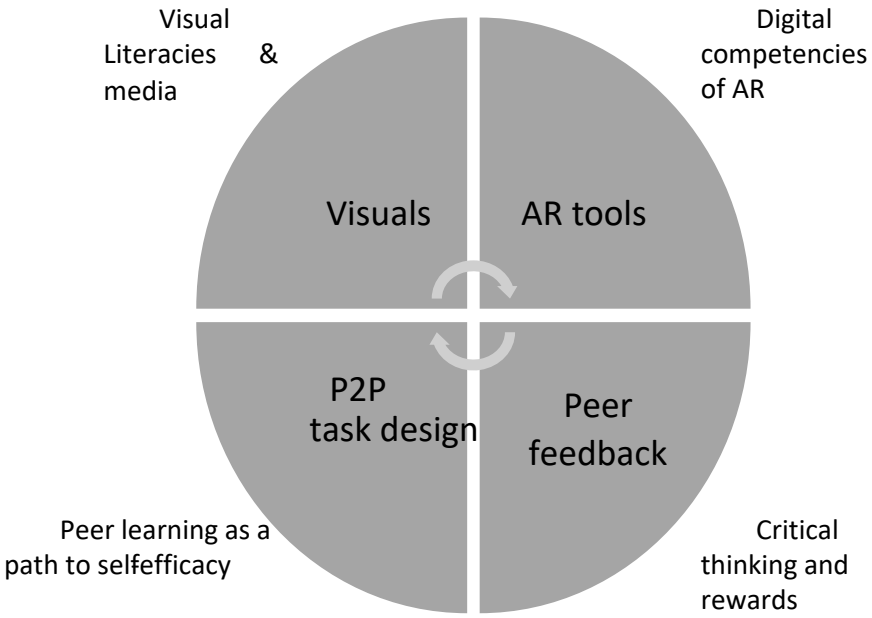

Fig 2. The iPEAR Schema

The iPEAR schema visualises the pedagogical framework. It is separated into four sections in constant interaction: Visuals (visual literacies and media), AR tools (digital competencies), P2P tasks design, and peer feedback culture (rewarding collaboration and critical thinking).The first element of the iPEAR pedagogy is visuals or visual literacy. The following definition comes from the 2011 ACRL Visual Literacy Competency Standards for Higher Education:

> Visual literacy is a set of abilities that enables an individual to effectively find, interpret, evaluate, use, and create images and visual media. Visual literacy skills equip a learner to understand and analyse the contextual, cultural, ethical, aesthetic, intellectual, and technical components involved in producing and using visual materials. A visually literate individual is both a critical consumer of visual media and a competent contributor to a body of shared knowledge and culture. (ARCL, 2011; Association of College and Research Libraries, 2019)

The term visual literacies were used in the plural to connotate the use of different forms of visual produced by various media, from comics and animation to video and avatars, to name a few. Learners and teachers could consider the role and potential of visuals in education, especially from a technology-enhanced learning perspective. Visual literacies could also be used in the plural (because of the abundance of visual media and visual creations) and be part of professional training (Themelis, 2022). The visible capital has much to offer. Educators must know that visuals disseminate meaning faster, but different audiences can interpret it differently. In other words, visual experiences, aesthetics, and ethics play a crucial role in understanding visual media and their products. Thus, educators and students could spend some time discussing the role of visual literacies, pros, and cons before the assignment. The standards of visual literacy could be equally helpful, as explained below.

The ARCL (Association of College and Research Libraries, 2011 & 2022) have studied visual literacy for over 12 years. It states that in an interdisciplinary, higher education environment, a visually literate individual can:

- Determine the nature and extent of the visual materials needed
- Find and access required images and visual media effectively and efficiently
- Interpret and analyse the meanings of images and visual media
- Evaluate images and their sources
- Use images and visual media effectively
- Design and create meaningful images and visual media
- Understand many of the ethical, legal, social, and economic issues surrounding the creation and use of images and visual media and access and use visual materials ethically

Thus, the educators could be trained on visual approaches and media within the disciplinary framework to understand the visual landscape better and what needs to be created for the course. How could they communicate and share visuals? What kind of copyrights and ethical questions could they pose, and what ethical considerations should they consider? Regarding the level of autonomy (pedagogy, andragogy), learners may ask for a different level of control and independence. In peer learning, a rubric with critical questions may trigger attention to the criticality and ethical implications of the visuals - conscious and unconscious bias. It is crucial to note that audio files could be added with AR tools, but there is always a visual marker that triggers the AR experience.

The second pillar is AR tools (digital skills)**.** Visual literacy is part of AR technologies that aim to extend realities with information. Educators must

invest significant time in choosing technologies to serve the disciplinary requirements, and they have to rely on the assistance of instructional designers or learning technologists. Educators could choose from a variety of AR apps that are marker-based (e.g., recognising a QR code), markerless (scanning the room) or location-based (relying on the device's GPS location, such as Pokémon Go). They could also consider different hardware platforms, from regular mobile phones to more elaborated HoloLens 2 (Augmented reality glasses). Unfortunately, educators face many challenges, such as engineers' technical jargon, complicated tutorials, and lack of training - complicating AR adoption in Higher Education.

The third pillar is P2P task design (according to the level of autonomy). The students need to fully understand why they get involved in an assignment, what they could get out of it and the usefulness of using technology. The students' and teachers' explanations may differ (Pask, 1975). The peers may find ways to instruct others more gradually or vividly because they have done so for themselves. For educators, explaining something they know very well could be automatic and may break down information into bigger chunks than the students can digest (Mazur,1997).

The University of Kentucky gave some evidence that P2P instruction could enhance course satisfaction and comprehension (Crouch, Watkins, Fagen, & Mazur, 2007). and students' conceptual understanding of science (Crouch & Mazur, 2012). Moreover, the approach could improve the retention of knowledge. " (Lambert, 2012, para 10), motivation and participation. (Simon & Cutts, 2012).

The P2P task design using AR heavily depends on AR's affordances for supporting remote or co-located collaboration. This includes mutual awareness (e.g., of peers represented by virtual avatars, as well as of shared spaces and objects such as anatomical models), communication (e.g. through voice chat and gestures) and mutual interaction and sharing (e.g. manipulating shared objects) (Radu et al., 2021). The task design might differ depending on whether the peer-to-peer interaction is remote or collocated: for example, remote peers need to be provided with some form of communication, such as voice chat, which is unnecessary for co-located ones. Co-located peers depend on consistent anchoring of shared models (e.g. a virtual house model) in the physical space, which is less relevant for remote learners. Both remote and co-located peers need to maintain awareness of their peers' actions (e.g., by pointers in the shared workspace).

The fourth part is the peer feedback culture, inclusive praxis, and rewards before, during, and after the designed activity. In creating a culture of constructive feedback, the students could create social netiquette and a growth

mindset initiative. Social netiquette refers mainly to productive ways to offer feedback without judgment and help everyone in the peer group participate. Educators' feedforward and rubrics could help students imitate the example for providing constructive feedback to peers. A growth mindset embraces mistakes as a way of knowing and regards learning as a life-long process. In plain words, a growth mindset is a concept in which skills and performances can be enhanced, and research shows that students' growth mindsets can predict higher achievement, well-being, and inclusive praxis (Dweck & Yeager, 2021). It is also crucial to reward those students who teach others, share their devices with others, enhance inclusive values and act as good models for others to imitate.

During the two-meter society of the pandemic, the P2P approach offers a supportive mechanism against alienated distance courses based on lectures (Vergroesen, 2020). Students were urged to co-create content, share personal experiences, analyse, evaluate, and retain knowledge while working with 'class partners'. Peers were the cure against the passive learning approach (online lecturing) and isolation of the pandemic. Research (Cohen, Kulik, Kulik, 1982; Freeman et al., 2014) showed that students could pass the courses and deepen their understanding if they worked with peers. Student-led assignments, collaborative reviews, and dialogues in breakout sessions are peer-to-peer active learning approaches that have become popular, especially during lockdowns. Educators and students enjoy personalised instruction from their peers and take more responsibility for their personal growth (Vergroesen, 2020).

Peer feedback could be a reliable source of scalable learning under three conditions:

a. The students should be offered rubrics to explain the role of collaboration and inclusive etiquette of interactions.

b. The activity should be designed with appropriate difficulty or different options that accommodate students' needs.

c. The students are willing and motivated to teach each other (rewards for peer collaboration).

Students need a rewarding system to work with peers to enhance motivation. Some educational systems concentrate on collaborative praxis from a young age, while others are more teacher-led and competitive. Therefore, students must understand why they must commit to the task, work, and teach each other as a form of inclusive and democratic engagement. The reward needs to be noticeable: grades, more choice, student agency, or peer recognition that promotes mutual respect. Parchoma (2005) and Pentland (2014, 2020) consider rewards as the social glue that builds excellent teamwork and boosts motivation and engagement. Pentland's studies at MIT-humans dynamic lab (2014) proved

that better performance and innovation are the product of effective and democratic collaboration rather than the high intellect potential of a few. If using AR technologies, the affordances of AR will also influence modes for giving and receiving feedback and rewards.

Basic guidelines

Educators must:

1) Be aware of the digital divide (ensure that the tools are inclusive and everyone has acquired the devices and the know-how). This could be done with training (by educators or peers) and sharing approaches. Sharing mobile phones with people they cannot afford to have.
2) Allow their students to form teams. Research shows that when students choose their peers, there is better collaboration (Zhang, Ding, & Mazur, 2017).
3) Design the task within the optimal level of difficulty that serves the learning outcomes.
4) Explain copyrights issues and visual ethics.
5) Provide peer feedback templates whenever needed.
6) Be cautious of visual culture (the impact of visuals in everyday life as the source of information, aesthetics, and learning).
7) Promote student agency in designing the task according to the disciplinary boundaries.
8) Talk about group dynamics: avoiding domineering behaviours (all voices heard). It is essential to note that the roles and abilities could be similar or different according to the P2P task design scenarios.
9) Enhance inclusive praxis for P2P instruction (facilitate learning for those with learning challenges with visual material and facilitate the update of the digital competencies.

Real examples

The iPEAR project created a compendium of praxis, in which the research findings were presented along with case studies as examples of creative implementation of the pedagogical framework. The summary will be available via the iPEAR website in April 2023. The educators could think of the following questions when using iPEAR pedagogy.

Having answered the previous questions, the educators must ensure that their students are ready to design the activity, underlining the inclusiveness in the approach of 'bring your own device' (BYOD). If some students still do not have an up-to-date mobile phone or device, they could be assigned a role to be

productive peer group members. It is important to note that educational institutions should provide the technologies that enhance learning in this time and age.

A case study from a secondary school in Athens, Greece, is designed by educator George Koinakis. Physics has excellent potential for visualisation. George Koinakis visualises content with AR using ARTutor, adds audio files to exercises as prompts and facilitates learning via collaboration, peer learning and problem-solving. His students create visual images to explain theories or visualise the solution to a problem. The key finding is that each team has a different visualisation, and healthy competition provides a motivational drive that comes from the respect of fellow students rather than the grades.

Another critical showcase is the Nevrolens app in medical and neuroscience education. It provides an augmented-reality experience for learning about the neuroanatomy of the rat brain. The brain system consists of a high-resolution 3D model of a rat brain model that can be collaboratively viewed from multiple angles and manipulated by several simultaneous users, both remote and co-located. Students can use the app to learn neuroanatomy as part of formal education or informally. The app is developed by IMTEL and the Kavli Institute at the Norwegian University of Science and Technology in collaboration with the iPEAR project. There are versions of the app for Hololens 2 available for download from Google Play and AppStore. A different app version, Pelvislens, focuses on pelvis anatomy, with several other anatomical regions to be developed.

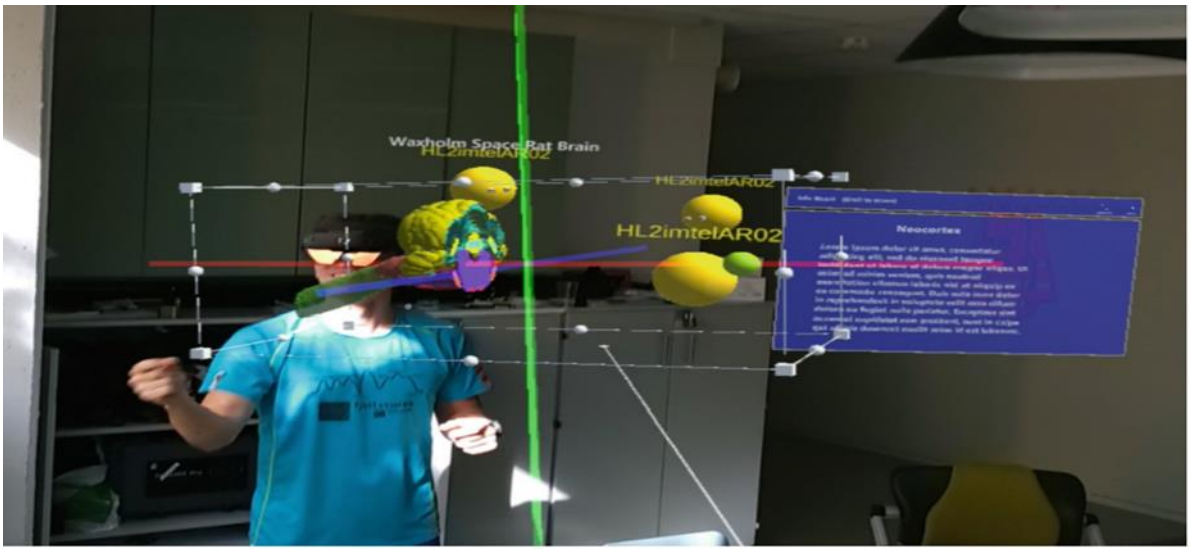

Fig 3. Nevrolens. A tester interacting with a colleague while performing brain dissection using the Nevrolens application.

Conclusion, limitations, and future directions

The iPEAR project research evaluated the holistic pedagogical design. The study of holistic pedagogy included 22 interviews with educators from Greece, Norway, and Germany and 214 survey data from their students. The research report will be published as a compendium of best practices (www.i-pear.eu) and presented in the MOOC in April 2023. P2P learning could promote lifelong learning, communication skills, and a culture of inclusion and constructive feedback (Themelis, 2022). AR adopts the visual language of the internet and enhances the digital skills needed. The findings showed that the two combined elements could promote students' engagement, motivation and empowerment while mirroring the social value of inclusiveness. At the same time, while one of the primary motivations for the project has been the pandemic and the corresponding need for inclusive *remote* P2P learning, most of the studies in this project are based on *co-located* peer learning with AR. This is partly due to the technical limitations and logistical challenges of enabling efficient and user-friendly remote peer-learning sessions. Undoubtedly more research is needed to adopt collaborative AR for remote P2P learning.

The instructional design has limitations. The most significant barrier is the lack of training and bridging the gap between research and praxis. The iPEAR pedagogy may be less effective for younger students or those from a cultural background with no collaborative assignment or inclusive approaches. The cost of technology and the internet is a significant barrier that cannot be ignored. As technology advances, AR tools become more user-friendly and cost-effective for educators. Billinghurst (2021) claims that the most significant limitations of adopting AR are social and ethical issues related to using visuals and human interaction limits.

With so many students dropping out of school, growing marginalisation of the poor in society, psychological and physical well-being in danger, and so many modern jobs requiring advanced digital skills, there has never been a more critical time to figure out new pedagogical paths. The post-Covid era calls for innovative and resourceful ways to promote inclusiveness, social learning and digital skills working harmoniously together to make students feel empowered lifelong learners that care for their peers.

References

Ahn, JN, Hu, D, Vega, M.(2020).Do as I do, not as I say. Using social learning theory to unpack the impact of role models on students' outcomes in education. *Soc Personal Psychol Compass*. 2020; 14:e12517. https://doi.org/10.1111/spc3.12517

Alrashidi, M., Almohammadi, K., Gardner, M., & Callaghan, V. (2017). Making the invisible visible: real-time feedback for embedded computing learning activity using a pedagogical virtual machine with augmented reality. In L. T. De Paolis, P. Bourdot, & A. Mongelli (Eds.), *Augmented reality, virtual reality, and computer graphics* (pp. 339–355). Springer International Publishing. https://doi.org/10.1007/978-3-319-60922-5_27

Association of College and Research Libraries (2022). *ACRL Visual Literacy Competency Standards for Higher Education*. http:// www.ala.org/acrl/standards/visualliteracy

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioural change. *Psychological Review*, 84(2), 191-215.

Bandura, A. (1971). *Social learning theory.* Prentice-Hall.

Billinghurst, M. (2021). Grand Challenges for Augmented Reality. *Frontiers in Virtual Reality*, https://doi.org/10.3389/frvir.2021.578080

Boud, D., Cohen, R., & Sampson, J. (1999). Peer Learning and Assessment. Assessment and *Evaluation in Higher Education*, 24(4), 413-426.

Boud, D., Cohen, R., & Sampson, J. (2014). *Peer learning in higher education: Learning from and with each other*. London: Routledge. https://doi.org/10.4324/9781315042565

Buchner, J. Buntins, K.l., Kerres, M. (2021) The impact of augmented reality on cognitive load and performance: A systematic review. *Journal of Computer Assisted Learning*. https://doi.org/10.1111/jcal.12617

Canning, N. (2010). Playing with heutagogy: Exploring strategies to empower mature learners in higher education. *Journal of Further and Higher Education*. https://doi.org/10.1080/03098770903477102

Cohen, P. A., Kulik, J. A., & Kulik, C.-L. C. (1982). Educational Outcomes of Tutoring: A Meta-analysis of Findings. *American Educational Research Journal*. https://doi.org/10.3102/00028312019002237.

Crouch, C. H., Watkins, J., Fagen, A.P., & Mazur, E. (2007). Peer instruction: Engaging students one-to-one, all at once, in Research-Based Reform of University Physics. *The American Association of Physics Teachers* http://www.percentral.org/document/ServeFile.cfm?ID=4990.

Dweck, C. & Yeager, D. (2021, August 25). Global Mindset Initiative Introduction: Envisioning the Future of Growth Mindset Research in Education. *SSRN* .https://ssrn.com/abstract=3911564 or http://dx.doi.org/10.2139/ssrn.3911564

Ellis, R., & Goodyear, P. (2019). *The education ecology of universities: integrating learning, strategy, and the academy*. Abingdon: Routledge. https://doi.org/10.4324/9781351135863

Ens, Lanir, J., Tang, A., Bateman, S., Lee, G., Piumsomboon, T., & Billinghurst, M. (2019). Revisiting collaboration through mixed reality: The evolution of groupware. *International Journal of Human-Computer Studies*. https://doi.org/10.1016/j.ijhcs.2019.05.011

Freire, P. (2017). *Pedagogy of the oppressed*. Penguin Classics. DOI: 10.2307/30023905

Hu Tianyu et al. (2017) Overview of augmented reality technology. *Computer Knowledge and Technology*, (34): 194-196 (in Chinese).

iPEAR resources (2023).*Toolkit*. https://i-pear.eu/resources/

Jandrić, P. (2017). *Learning in the Age of Digital Reason.* Sense Publishers, DOI.10.1007/978-94-6351-077-6.

Keenan, C. (2014, November 27). *Mapping student-led peer learning in the UK*. York: Higher Education Academy Advance HE. https://www.advance-he.ac.uk/knowledge-hub/mapping-student-led-peer-learning-uk

Kuhfeld, M., Soland, J. & Lewis, K. (2022). Test Score Patterns Across Three COVID-19-impacted School Years. (EdWorkingPaper: 22-521). *Annenberg Institute at Brown University*. https://doi.org/10.26300/ga82-6v47

Lackovic, N. (2021, March 5) *Using visual media to enhance online learning*. Times Higher Education https://www.timeshighereducation.com/campus/using-visual-media-enhance-online-learning

Lambert, C. (2012, March-April). Twilight of the lecture. *Harvard Magazine*. (http://harvardmagazine.com/2012/03/twilight-of-the-lecture

Loup-Escande, E., Frenoy, R., Poplimont, G., Thouvenin, I., Gapenne, O., &Megalakaki, O. (2017). Contributions of mixed reality in a calligraphy learning task: Effects of supplementary visual feedback and expertise on cognitive load, user experience and gestural performance. *Computers in Human Behavior*. https://doi.org/10.1016/j.chb.2017.05.

Mazur, E. (1997). *Peer instruction: A user's manual.* Upper Saddle River, NJ: Prentice-Hall.

Mystakidis, Christopoulos, A., & Pellas, N. (2022). A systematic mapping review of augmented reality applications to support STEM learning in higher education. *Education and Information Technologies, 27*(2), 1883–1927. https://doi.org/10.1007/s10639-021-10682-1

Nesenbergs, Abolins, V., Ormanis, J., & Mednis, A. (2021). Use of augmented and virtual reality in remote higher education: A systematic umbrella review. *Education Sciences*, 11(1), 1–12. https://doi.org/10.3390/educsci1101000

O'Donnell, A. M., & King, A. (2014). *Cognitive perspectives on peer learning*. London: Routledge. https://doi.org/10.4324/9781410603715

Osika, A., MacMahon, S., Lodge, J.M., Carroll, A. (2022, March 18)Emotions and learning: what role do emotions play in how and why students learn? *The Higher Education*. https://www.timeshighereducation.com/campus/emotions-and-learning-what-role-do-emotions-play-how-and-why-students-learn

Palmer, K. & Blake, D. (2018, November 08) How to Help Your Employees Learn from Others. *Harvard Bussiness Review* https://hbr.org/2018/11/how-to-help-your-employees-learnfrom-each-other

Parchoma, G. (2005). Roles and relationships in virtual environments: A model for adult distance educators extrapolated from leadership in experiences in virtual organisations. *International Journal on E-Learning*. https://www.thefreelibrary.com/Roles+and+relationships+in+virtual+environments%3a+a+model+for+adult...-a0138662590

Pentland, A. (2014). *Social Physics: how good ideas spread - the lessons from a new science*. The Penguin Press. https://doi.org/10.1007/s11138-014-0276-6

Pentland, A. (2020, March 25). Managing the Flow of Ideas in a Pandemic. *MIT Sloan Management Review*. https://sloanreview.mit.edu/article/managing-the-flow-of-ideas-in-a-pandemic/

Radu, J., Joy, T., Bowman, Y., Bott, I., Schneider, B. (2021, April). A Survey of Needs and Features for Augmented Reality Collaborations in Collocated Spaces. *Proc. ACM Hum.-Comput. Interact. 5, CSCW1*. https://doi.org/10.1145/3449243

Riese, H., Samara, A., & Lillejord, S. (2012). Peer relations in peer learning. *International Journal of Qualitative Studies in Education,* 25(5), 601-624.

Themelis, C (2022). *Pedagogy of Tele-Proximity for eLearning Bridging the distance with social physics*. Routledge. https://doi.org/10.4324/9781003270324

The University of Kentucky, UK.(2022). *Online Peer instruction.* https://www.uky.edu/elearning/peerinstruction.

UNESCO(2020).Addressing the gender dimensions of COVID-related school closures. *UNESCO Digital Library*.https://unesdoc.unesco.org/ark:/48223/pf000037337

Vergroesen, L.L (2020, August 27) Why Peer Learning is the Future of Remote Learning. *Eduflow*. https://www.eduflow.com/blog/why-peer-learning-is-the-future-of-remote-learning

Zhang, P., Ding, L. & 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*. DOI: 10.1103/PhysRevPhysEducRes.13.010104

Appendix

Appendix A: Educator Checklist

✔ **Technical issues- digital skills for AR**

- Am I fully aware of the AR tools I will use?
- Do I have an alternative plan if, for some reason, the AR tool is not working for all mobile phones?
- Have I designed a pilot assignment to ensure all students are on the same page (technical skills)?
- Have the students the digital skills to work in an iPEAR scenario?
- Could students work remotely?
- Could students work synchronously and asynchronously?
- Would the chosen software and software support the selected work mode (remote/co-located, synchronous/asynchronous)?

✔ **Visuals – content creation and media**

- Have the students discussed the role of visuals in learning?
- Are the students informed of the visual data copyrights and ethics?
- Are students aware of visual media to use?
- Is the visual quality of media sufficient for the purpose?
- Is there visual support for P2P processes, such as peer avatars, pointers indicating user activities, and other ways of maintaining awareness of shared virtual workspace?

✔ **Peer learning task design**

- Have the students had prior collaborative learning experiences?
- Are the students satisfied with collaborative learning?
- Are the students able to produce visuals for the learning outcomes?
- Are the students able to use the specific AR tools?
- Are the students aware of the inclusive nature (Sharing ideas, devices and assessment) of peer learning?

- Have the students had choices in the visual by-product?
- Could the students choose their peers?
- Could the students have different roles?
- Does the peer learning task design consider AR technology's affordances?

✔ **Peer feedback culture**

- Is the iPEAR assignment rewarding (grades) and motivational (creative and critical thinking) for the students?
- Could students, according to their level of autonomy, assess each other's work?
- Have I provided assessment criteria?

List of Figures