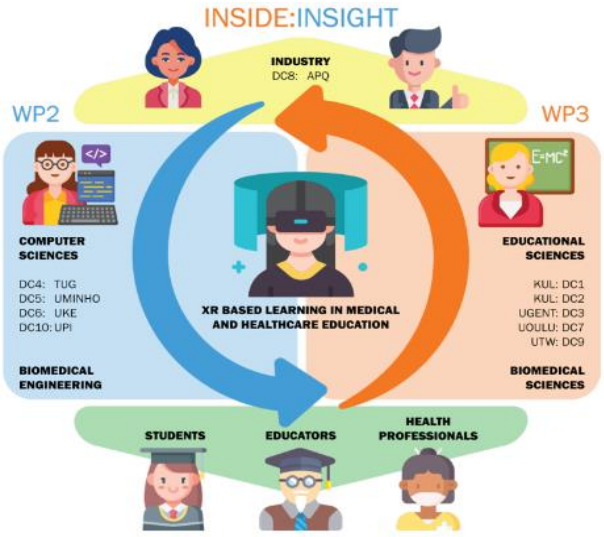
INSIDE:INSIGHT Call for applications for 10 Doctoral (PhD) Training Positions in developing and assessing XR technologies in (bio)medical education.

Offer Description

INSIDE:INSIGHT is a Doctoral Network funded by the Horizon Europe programme of the EU. It is composed of 12 partners across Europe, Canada and New-Zealand and includes leading scientists from academia and industry. Within the consortium there is expertise in educational theories and technologies, human anatomy, computer vision and sciences, biomedical engineering, medical imaging and surgery.
INSIDE:INSIGHT proposes 10 independent doctoral research projects with the ambition of providing its trainees with a comprehensive understanding of educational technologies in the biomedical field. Through its research and training activities, the INSIDE:INSIGHT project will contribute to scientific advancement and innovation in Europe, ultimately leading to societal and economic benefits.



Graduates of INSIDE:INSIGHT will be well-prepared for a career in as well as outside academia with an innovative and beyond state-of-the-art view on different aspects of educational technologies. Moreover, the students will be trained in transferable skills, such as communication, entrepreneurship, intellectual property rights and ethics. Participating in INSIDE:INSIGHT offers doctoral candidates many unique opportunities, including:

- A project as Marie Skłodowska Curie trainee in one of the participating institutions with the objective of receiving a doctoral degree (PhD).
- State-of-the art, exciting research in an international consortium with highly integrated projects.
- Expert training in basic and applied research, along with a thorough understanding of entrepreneurship and valorisation.
- A research training period in another consortium member's lab lasting from a few weeks up to three months, performed in a different country.
- Gross Salary according to EU guidelines for Marie Skłodowska Curie trainees, including mobility payments and family allowances where applicable.

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INDIVIDUAL PROJECTS DETAILS

Application process

The selection procedure will be open, transparent and merit-based, fully aligned with the Code of Conduct for the Recruitment of Researchers. Although the selection will be based on the quality of applications, gender balance will also be considered.

Candidates can apply for a **maximum of three PhD projects** within the INSIDE:INSIGHT project and the applications need to be submitted separately. Applications (in English) must include:

1. a **cover letter** which will also include the motivation for the position, emphasizing the candidate's strength regarding the project and the requirements (max 3 pages);
2. a **CV** (max 2 pages);
3. a scan of the **relevant diplomas or certificates** that formally entitle the candidate to embark on a doctorate. Typically, these documents will include Bachelor's and Master's Degree certificates. In case the Master's Degree has not been obtained yet at the closing date for application, the candidate has to submit a declaration signed by their supervisor or University official stating that the degree will be obtained by the time of PhD enrolment;
4. **Letter of Recommendation** from two appropriate referees or contact details of two referees.

Application documents in a single pdf file (< 3 MB) should be either sent by email to the relevant project supervisors (see email address in individual project descriptions) OR submitted through the recruitment platform if available. The subject line of the email must be in the following format: ***"INSIDE:INSIGHT application for Project_DC#".***

Applications deadline is officially 15th December 2024; **please review the dates for each project separately where applicable**. **Specific DC projects may be closed later** depending on their specific deadlines set by the Hosting Institution/Institutional recruitment platforms.

Applicants are advised to familiarise themselves thoroughly with the INSIDE:INSIGHT project and individual projects for which they apply and be ready to answer questions on their chosen topics. INSIDE:INSIGHT will select Doctoral Candidates through a 2-step recruitment process. After reviewing all project applications, supervisors of individual projects will contact selected applicants to organise an initial screening interview by videoconferencing. The most promising candidates will then be invited for a second online interview with a specific assignment which will be attended by several other project supervisors. Please note that application deadline and timing of the selection process might differ between Institutes.

Research projects offered by INSIDE:INSIGHT

DC	Project Title	Primary Supervisor Contact	Institution	EU State
1	Investigating the educator's role in virtual learning environments for anatomical and clinical skills training	Prof. Dr F. Depaepe fien.depaepe@kuleuven.be Recruitment Platform www.kuleuven.be/personeel/jobsite/jobs/phd	Katholieke Universiteit Leuven (KUL)	BE
2	Acceptance of technology-enhanced learning materials in medical and healthcare education	Prof. Dr. E. Vereecke evie.vereecke@kuleuven.be Recruitment Platform www.kuleuven.be/personeel/jobsite/jobs/phd	Katholieke Universiteit Leuven (KUL)	BE

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3	Instructional design and effectiveness evaluation of XR applications in anatomical education	Prof. Dr. Wouter Willaert wouter.willaert@ugent.be	Universiteit Gent (UGENT)	BE
4	Authoring tools for medical and healthcare education applications in XR	Assoc. Prof. Dr. D. Kalkofen kalkofen@tugraz.at	Graz University of Technology (TUG)	AT
5	Gamification of teaching in medical and healthcare education with AI and serious games	Prof Dr. V. Alves valves@di.uminho.pt	University of Minho (UMINHO)	PT
6	Integration and testing of uni- and multimodal XR learning scenarios with real-world medical data.	Prof. Dr. J. Egger jan.egger@uni-due.de	University Hospital Essen (UKE)	DE
7	Fostering interprofessional healthcare collaboration: an XR-enhanced pedagogical model for developing SRL/SSRL skill.	Prof. Dr. S. Järvelä sanna.jarvela@oulu.fi Recruitment Platform https://oulunyliopisto.varbi.com/what:job/jobID:764965/	University of Oulu (UOULU)	FI
8	SurgiLearnX: Revolutionizing surgical training with XR-enhanced MOOC platform.	Dr. D. Salzmann daniela.salzmann@apoqlar.com Prof. Dr. J. Egger jan.egger@uni-due.de Recruitment contact human.resources@apoqlar.com	Apoqlar (APQ) University Hospital Essen (UKE)	DE
9	Revolutionizing healthcare training: innovative performance monitoring to support error-recovery in simulation-based psychomotor skills training	Dr. M. Groenier m.groenier@utwente.nl Recruitment Platform https://utwentecareers.nl/	University of Twente (UTW)	NL
10	Mixed Reality with both visual perception and manual interaction to understand and learn complex assembled structures for anatomy learning and clinical tasks training.	Prof. Dr. V. Ferrari vincenzo.ferrari@unipi.it	University of Pisa (UPI)	IT

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Detailed Projects Description

DC1	**Investigating the educator's role in virtual learning environments for anatomical and clinical skills training**
Host Institution	KU Leuven (KUL)
Doctoral School	KU Leuven
Primary Supervisor	Prof. Dr. F. Depaepe
Application Platform	http://www.kuleuven.be/personeel/jobsite/jobs/phd; Additional information contacts: fien.depaepe@kuleuven.be; evie.vereecke@kuleuven.be
Internal Deadline	20 January 2025
Planned Duration	36 months
Subject Area	Medical education; XR technology, technology enhanced education; immersive learning

Introduction: Educational technologies, such as Mixed (MR), Augmented (AR) and Virtual Reality (VR), together referred to as eXtended Reality (XR), can revolutionize the way we learn and teach, also in the domain of medical education. However, there is only limited evidence on the effectiveness of these tools in educational settings. The current PhD project will focus on the teacher's role in XR learning environments for anatomical and clinical skills in view of fostering students' cognitive and non-cognitive learning outcomes in the domain of anatomical and clinical skills training.

Objective:
Science objectives: 1) To design guidelines for development of an educator dashboard for (individual) VR environments, based on instructional design principles and stakeholders' interviews. 2) To evaluate the impact of debriefing on cognitive and non-cognitive learning outcomes in immersive learning (individual and collaborative setting). 3) To investigate the effectiveness of dashboard implementation in providing feedback (individual and collaborative setting). 4) To develop guidelines for providing effective feedback and facilitating meaningful dialogue when using VR.
Training objectives: 1) To learn to communicate and interact with different users (students, health professionals, educators). 2) To gain insight in the role of a developer, software development and digital skills. 3) Collaborative problem solving and providing feedback.

Expected Results: R1: Ability to provide guidelines on how feedback and debriefing can affect cognitive and non-cognitive learning outcomes in medical skills training. **R2:** Development and implementation of an educator dashboard in collaborative and individual settings, to enhance the effectiveness of debriefing and will facilitate meaningful dialogue, resulting in a higher learning experience and performance of the students.

Secondments: (1) 3 months at TUG (M12-14) will give the DC an insight into dashboard development; **(2)** 3 months at UOULU (M17-19) will provide insight into collaborative and interprofessional learning, investigating role of educator in optimizing collaboration process; **(3)** 4 months at UTW (M24-27) for the implementation of VR simulations in clinical skills training in different student population.

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in educational sciences, psychology, computer sciences, (bio)medical sciences, or equivalent. Knowledge of educational and behavioral research and a proven track record are required. Additionally, practical experience in the use of technology and ICT in education and training are a plus. The candidate should be familiar with basic research techniques (e.g., statistical and computer sciences techniques).

Recommended reading:

- **Simulation-based learning in higher education: A meta-analysis**. Chernikova, O., Heitzmann, N., Stadler, M., Holzberger, D., Seidel, T., & Fischer, F. (2020). *Review of Educational Research, 90*(4), 499–541.
- **The promise and pitfalls of learning in immersive virtual reality.** Mayer, R. E., Makransky, G., & Parong, J. (2023). *International Journal of Human–Computer Interaction*, *39*(11), 2229-2238.
- **Towards hybrid human-AI learning technologies.** Molenaar, I. (2022). *European Journal of Education*, *57*(4), 632-645.
- **Toward a framework for analyzing adaptive digital games research effectiveness** .Vanbecelaere, S., Demedts, F., Reynvoet, B., & Depaepe, F. (2023). *International Journal of Serious Games*, *10*(4), 77-91.

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DC2	**Acceptance of technology-enhanced learning materials in medical and healthcare education**
Host Institution	KU Leuven (KUL)
Doctoral School	KU Leuven
Primary Supervisor	Prof. Dr. Evie Vereecke
Application Platform	http://www.kuleuven.be/personeel/jobsite/jobs/phd; Additional information contacts: fien.depaepe@kuleuven.be; evie.vereecke@kuleuven.be
Internal Deadline	6 January 2025
Planned duration	36 months
Subject Area	Anatomy; medical education; XR technology; immersive learning

Introduction:

Extended Reality (XR) applications have the power to revolutionize medical and healthcare education. By offering various levels of immersion and engaging multiple senses, XR technologies can create highly personalized and interactive learning experiences. This adaptability allows educational content to be fine-tuned to each learner's unique needs, background, and specific learning objectives, thereby enhancing educational outcomes.

However, despite its promising benefits, XR remains not widely adopted in medical and healthcare training. This PhD project aims to bridge this gap by investigating the acceptance and adoption of technology-enhanced learning materials in the field. The research will involve a comprehensive analysis of user acceptance among health professionals, educators and students, with a particular focus on identifying the factors that facilitate or hinder XR adoption. By embracing the diversity of perspectives and needs within these groups, this project seeks to uncover actionable insights to support the effective integration of XR in educational settings.

This is an exciting opportunity for prospective PhD students interested in pioneering research at the intersection of technology and education, with the potential to make a significant impact on the future of healthcare training.

Objective:

Science objectives: 1) To measure the acceptance of different XR applications within medical and healthcare education. 2) To identify which factors affect the intention of the user (i.e., educator, student, health professional) to use technology-enhanced learning materials. 3) To develop guidelines for increasing user's acceptance of XR applications (e.g. design, social, environment, pedagogical, psychological).

Training objectives: 1) To learn to communicate and interact with different users (students, health professionals, educators). 2) To understand various XR applications in medical and healthcare education. 3) To obtain insight in educational theories.

Expected Results: R1: Measure the acceptance of different user groups (educators, students, health professionals) for different XR applications (AR+haptic, gamification, digital anatomical specimens, VR and clinical simulations) and identify factors (design, environment, social, pedagogical, psychological) that could enhance acceptance levels.

Secondments: (1) 2 months at UTW (M16-17) learning about measuring the acceptance of simulations for clinical skills training; educational, digital and clinical skills; **(2)** 2 months at UBC (M20-21) with focus on acceptance of XR applications and educational skills; **(3)** 2 months at UMINHO (M24-25) with focus on acceptance of serious games, expertise in AI applications and digital skills; **(4)** 2 months at UPI (M28-29) with focus on acceptance of AR and manual interaction as well as expertise in surgical skills training.

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in educational sciences, psychology, computer sciences, (bio)medical sciences, health sciences or equivalent. Knowledge of human anatomy and affinity and/or experience with the medical field are required. Additionally, practical experience in the use of technology and ICT in education and training are a plus. The candidate should be familiar with basic research techniques (e.g., statistical and data analysis techniques). Creativity and enthusiasm are considered important assets.

Recommended reading:

- **The promise and pitfalls of learning in immersive virtual reality.** Mayer, R. E., Makransky, G., & Parong, J. (2023). *International Journal of Human–Computer Interaction*, *39*(11), 2229-2238.

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- **Applying the UTAUT Model to Explain the Students' Acceptance of Mobile Learning System in Higher Education.** M. A. Almaiah, M. M. Alamri and W. Al-Rahmi, " in *IEEE Access*, vol. 7, pp. 174673-174686, 2019, doi: 10.1109/ACCESS.2019.2957206.
- **Educational UTAUT-based virtual reality acceptance scale: a validity and reliability study**. Ustun, A.B., Karaoglan-Yilmaz, F.G. & Yilmaz, R. *Virtual Reality* **27**, 1063–1076 (2023). https://doi.org/10.1007/s10055-022-00717-4

DC3	**Instructional design and effectiveness evaluation of XR applications in anatomical education**
Host Institution	Universiteit Gent (UGENT)
Doctoral School	Universiteit Gent
Primary Supervisor	Dr. Wouter Willaert
Email address for applications	wouter.willaert@ugent.be
Internal Deadline	15 December 2024
Planned duration	36 months + 12 months (UGENT)* * A PhD trajectory at UGENT requires a minimum of 4-years
Subject Area	Health and educational sciences; interdisciplinary doctorate

Introduction:
Extended Reality (XR) applications possess the potential to transform medical and healthcare education significantly. By providing varying levels of immersion and engaging multiple sensory modalities, XR technologies facilitate the creation of highly personalised and interactive learning experiences.
Nevertheless, despite these promising advantages, the adoption of XR in medical and healthcare training remains limited. This PhD project aims to address this gap by exploring the instructional design principles of technology-enhanced learning resources within the field. The research will encompass a thorough examination of instructional design principles in order to facilitate an effective implementation of XR in educational environments and enhance learning outcomes.
This project presents an exciting opportunity for prospective PhD candidates interested in pioneering research at the intersection of technology and education, with the potential to significantly influence the future of healthcare training.

Objectives:
Science objectives: 1) To scan anatomical specimens and develop high-fidelity 3D models that can be integrated in virtual learning environments; 2) To define a list of requirements to which an anatomical XR learning environment needs to comply (promote presence and agency through e.g., the desired amount of immersion, interactivity and collaboration, assessment features); 3) To create a study framework to evaluate the effectiveness of the developed anatomical XR learning environments on medical students' learning outcomes (both factual and conceptual knowledge) as well as the student cognitions (cognitive load, motivation, self-efficacy).
Training objectives: 1) Development of anatomical knowledge and dissection skills; 2) Creation of 3D scanned anatomical specimens; 3) Educational/pedagogical insights: gain expertise in instructional design principles and educational theories to effectively align XR environments with learning objectives. Acquire skills required to conduct research in educational settings; 4) Technological insights into the development of XR applications.

Expected Results: (R1) Assimilate knowledge about anatomical sciences, learning theories; **(R2)** XR applications development capability.

Secondments: 1) 3 months at TUG (M9-11) to deepen the technical knowledge on software development in XR learning environments; **2)** 3 months at UKE (M13-15) to familiarize with the challenges of interdisciplinary collaborations and with the developed prototypes of the XR environments before implementation; **3)** 3 months at APQ (M20-22) to familiarize with the practical integration of academic innovations into real-world applications, focusing on understanding technology valorization and IPR in the context of the project; to gain insight into product development processes, technology transfer, and IP strategies, and fostering collaboration.

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in health sciences (medicine, physiotherapy, sports, biomedicine, audiology/logopaedics). Knowledge of human anatomy and a proven track record are required. Additionally, a strong interest in educational sciences (e.g., educational research, instructional design) and immersive environments will be a plus. Knowledge of Dutch is not required but a plus.

Recommended reading:
- **The promise and pitfalls of learning in immersive virtual reality.** Mayer, R. E., Makransky, G., & Parong, J. (2023). *International Journal of Human–Computer Interaction*, *39*(11), 2229-2238.

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- **From bones to bytes: Do manipulable 3D models have added value in osteology education compared to static images?** Vandenbossche V, Valcke M, Willaert W, Audenaert E., *Med Educ*. 2023 Apr;57(4):359-368. doi: 10.1111/medu.14993. Epub 2022 Dec 9. PMID: 36453018**.**
- **The Cognitive Affective Model of Immersive Learning (CAMIL): A theoretical research-based model of learning in immersive virtual reality**.Makransky, G., & Petersen, G. B. (2021). *Educational Psychology Review*, 33(3), 937–958. https://doi.org/10.1007/s10648-020-09586-2

DC4	**Authoring tools for medical and healthcare education applications in XR**
Host Institution	Graz University of Technology (TUG)
Doctoral School	Graz University of Technology
Primary Supervisor	Assoc. Prof. Dr. Denis Kalkofen
Email address for applications	kalkofen@tugraz.at
Internal Deadline	31 January 2025
Planned duration	36 months
Subject Area	Augmented Reality, Virtual Reality, Visual Computing, Human-Computer Interaction

Introduction:
This project aims at developing novel Augmented Reality (AR) and Virtual Reality (VR) environments for educating medical students. This includes novel tools for creating educational VR and AR content for the medical sector and novel tools for medical content delivery in AR and VR environments.

Objectives:
Science objectives: 1) To define the requirements a medical and healthcare educational XR app and corresponding authoring tool must meet (e.g., the desired amount of immersion, interactivity and collaboration, platform compatibility, compatible data sources, assessment features); 2) To establish guidelines for content standardization (for 3D models, animations, interactive elements, and other instructional content; 3) To develop algorithms for semi-automatic content creation from existing resources (e.g., textbooks, 3D models, medical imaging, procedural videos); 4) To develop an authoring tool for easy integration of content and scenarios into an XR application by educators. Training objectives: 1) Technical proficiency: Develop proficiency with XR technologies, software tools, and programming languages essential for XR content creation and authoring. This includes knowledge of industry best practices, optimization techniques, and quality assurance standards to ensure the practical viability of XR authoring solutions; 2) Educational insights: Gain expertise in instructional design principles and educational theories to effectively align XR content with learning objectives; 3) Biomedical domain knowledge: Acquire a solid understanding of biomedical sciences, medical procedures, and anatomy to facilitate content extraction and authoring).

Expected Results: (R1) The project aims to bridge the knowledge gap between (bio)medical educators and XR developers by creating an innovative authoring tool that simplifies the process of implementing immersive XR experiences for complex (bio)medical topics. The authoring tool will build on top of a comprehensive set of requirements and guidelines to ensure compatibility with common platforms, devices, learning objectives and user cases.

Secondments: (1) 2 months at UGENT (M13-14) to gain understanding of biomedical sciences, medical procedures, and anatomy; **(2)** 2 months at APQ (M24-26) to deepen software development proficiency, learn industry best practices, and how to deliver market-ready healthcare software; **(3)** 2 months at KUL (M33-34) to demonstrate the developed prototypes to the end users (medical educators) and iteratively refine them.

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in Computer Science or a related area, with knowledge in Virtual and Augmented Reality (VR/AR) technologies and with knowledge in visual computing, with a focus on human-computer interaction. Practical experience in software engineering, including experience with AR and VR development tools, such as Unity and C#, is a plus. Candidates should be a team player with good communication skills.

Recommended reading:

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- **Retargeting Technical Documentation to Augmented Reality**
  Peter Mohr, Bernhard Kerbl, Michael Donoser, Dieter Schmalstieg and Denis Kalkofen. *Proceedings of ACM Conference on Human Factors in Computing Systems (CHI), 2015,* doi: *10.1145/2702123.2702490.*
- **Retargeting Video Tutorials Showing Tools With Surface Contact to Augmented Reality**
  Peter Mohr, David Mandl, Markus Tatzgern, Eduardo E. Veas, Dieter Schmalstieg, Denis Kalkofen. *Proceedings of ACM Conference on Human Factors in Computing Systems (CHI), pp.6547--6558, 2017,* doi: *10.1145/3025453.3025688.*
- **AR Hero: Generating Interactive Augmented Reality Guitar Tutorials**
  Lucchas Ribeiro Skreinig, Ana Stanescu, Shohei Mori, Frank Heyen, Peter Mohr, Michael Sedlmair, Dieter Schmalstieg and Denis Kalkofen. IEEE Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW), pp.395--401, 2022, doi: 10.1109/VRW55335.2022.00086.

DC5	**Gamification of teaching in medical and healthcare education with AI and serious games**
Host Institution	Universidade do Minho (UMINHO)
Doctoral School	Universidade do Minho
Primary Supervisor	Prof. Dr. Vítor Manuel Rodrigues Alves
Email address for applications	valves@di.uminho.pt
Internal Deadline	15 December 2024
Planned duration	36 months + 12 months (UMINHO)* * The Biomedical Engineering PhD program at UMINHO requires a minimum of 48 months
Subject Area	Biomedical Engineering; Artificial Intelligence

Introduction:
This project aims to explore the integration of gamification, artificial intelligence (AI), and serious games in medical and healthcare education to enhance student engagement, motivation, and knowledge retention. It will contribute to the existing knowledge while evaluating AI's role in tailoring educational content and providing real-time feedback. The project also seeks to identify challenges in implementing these technologies and propose solutions. Expected outcomes include improved educational practices, positive student experiences, and increased adoption of AI-driven gamification by institutions.

Objectives:
Science objectives: 1) To contribute to the existing body of knowledge on gamification, AI and serious games in medical and healthcare education, and offer insights that can benefit developers, educators, institutions, and learners (students, health professionals). 2) To determine whether the integration of gamification elements based on AI, including serious games, in medical and healthcare education enhances student engagement, motivation and knowledge retention. 3) To examine the role of AI in tailoring educational content, adapting to individual learner needs, and providing real-time feedback to improve the learning experience. 4) To identify the challenges and limitations in the implementation of these technologies and strategies and propose solutions to overcome them.
Training objectives: 1) Effective Assessment and Feedback: Learn how to use AI tools for real-time assessment and personalized feedback and develop strategies for providing constructive feedback to students. 2) Best Practices and Ethical Considerations: Explore best practices for implementing gamification and technology in a responsible and ethical manner and understand potential ethical challenges and how to address them. 3) Accessibility and Inclusivity: Understand the importance of accessibility and inclusivity in medical education and learn how to design gamified content and serious games that accommodate diverse learning needs.

Expected Results: (R1) increased competence in using gamification and AI technology, successful integration of these elements in medical and healthcare education, improved student engagement and personalization, ethical awareness, and enhanced accessibility and inclusivity; **(R2)** positive student outcomes, including improved performance and satisfaction, greater adoption and integration of these methods by institutions, and participants' ability to create high-

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quality learning resources. **(R3)** Feedback and satisfaction from participants, coupled with their ongoing commitment to learning, are also expected outcomes, along with a demonstrated ability to monitor and evaluate the impact of gamification in education.

Secondments: 1) 3 months at UBC (M12-14) to contribute to effective design and implementation of the gamified curriculum and serious games; **2)** 3 months at UKE (M18-20) to develop personalized learning algorithms, data analysis, and feedback systems to enhance the AI component.

Enrolment in Doctoral degree(s): Universidade do Minho (UMINHO)

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in Biomedical Engineering and/or Artificial Intelligence. Knowledge of artificial intelligence/machine learning, computer vision, and a proven track record are required. Additionally, practical experience in medical image processing, serious games development will be a plus. The candidate should be familiar with basic techniques (e.g., programming, graphics processing, audio processing). Candidates should be familiar with gamification principles, game design, educational technology, project management, user testing and assessment.

Recommended reading:

- **The fundamentals of Artificial Intelligence in medical education research**: AMEE Guide No. 156. Tolsgaard MG, Pusic MV, Sebok-Syer SS, Gin B, Svendsen MB, Syer MD, Brydges R, Cuddy MM, Boscardin CK. Med Teach. 2023 Jun;45(6):565-573. doi: 10.1080/0142159X.2023.2180340
- **Gamification in medical education: identifying and prioritizing key elements through Delphi method.** Wang, Y. F., Hsu, Y. F., Fang, K. T., & Kuo, L. T. *Medical Education Online*, *29*(1). (2024). https://doi.org/10.1080/10872981.2024.2302231
- **Game-based learning in medical education**. Xu, M., Luo, Y., Zhang, Y., Xia, R., Qian, H., & Zou, X. *Frontiers in Public Health*, *11*, 1113682. (2023). https://doi.org/10.3389/FPUBH.2023.1113682/BIBTEX

DC6	**Integration and testing of uni- and multimodal XR learning scenarios with real-world medical data.**
Host Institution	University Hospital Essen (UKE)
Doctoral School	University Hospital Essen
Primary Supervisor	Prof. Dr. Jan Egger
Email address for applications	jan.egger@uni-due.de
Internal Deadline	15 December 2024
Planned duration	36 months
Subject Area	Biomedical Engineering

Introduction: This project aims to develop Mixed Reality (MR) technologies and methodologies, focusing on the integration of Augmented Reality (AR) with manual interaction, that can help learners achieve a better 3D understanding of complex assembled objects – such as anatomical structures. In addition, we want to evaluate the potential of commercially available haptic/force feedback gloves to improve the understanding of assembled objects under MR, combining visual cues and manual interaction.

Objective:

Science objectives: 1) To define the requirements an integration of uni- and multimodal XR learning tools with real-world medical data must meet (e.g., the desired amount of immersion, interactivity and collaboration, platform compatibility, compatible data sources, assessment features). 2) To establish guidelines for scenario standardization for 3D models, animations, interactive elements, and other instructional content (e.g., file formats, structure of metadata, APIs). 3) To research and develop tools and apps for uni- and multimodal XR learning scenarios with real-world medical data. 4) To develop an overall framework for an easy integration and extension of new medical content and clinical skills scenarios that can be used as XR learning tools.

Training objectives: 1) Technical proficiency: Develop proficiency with XR technologies, software tools, and programming languages essential for XR learning scenarios using real-world medical data. This includes knowledge of best practices, optimization techniques, and quality assurance standards to ensure the practical viability of XR solutions. 2) Medical and

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clinical application insights: Gain expertise in learning design principles and theories to effectively align XR content with the learning objectives in medical and healthcare education. 3) (Bio)medical domain knowledge: Acquire a solid understanding of biomedical sciences (which incorporates anatomy), medical and clinical procedures to facilitate tool development and implementation in medical and healthcare education).

Expected Results: (R1) A document outlining the requirements of the developed tool and requirements of biomedical learning XR apps, including guidelines for the standardization of required content. **(R2)** A framework for uni- and multimodal XR learning scenarios with real-world medical data that can easily be extended with new content and scenarios.

Secondments: 1) 3 months at UGENT (M11-13) to gain an understanding of learning goals and teaching/training approaches in (bio)medical education; **2)** 4 months at UPI (M20-23) to deepen technical proficiencies, learn technical best practices and how to produce suitable solutions for users. **3)** 2+2 months at KUL & UTW (M28-31) to demonstrate the developed prototypes to the end users and iteratively refine them.

Project-specific selection criteria: Candidates should have a Master's degree in biomedical engineering or a similar education level. Knowledge of machine and deep learning and computer vision, and a proven track record are required. Additionally, practical experience in medical image processing, object detection and segmentation will be a plus. The candidate should be familiar with basic research techniques (e.g., medical image preprocessing, feature extraction, image segmentation, image registration and data augmentation). Candidates should be familiar with Python and relevant libraries such as TensorFlow, Keras, OpenCV or PyTorch.

Recommended reading:

- "**Development of a Surgical Navigation System based on Augmented Reality using an Optical see-through Head-mounted Display**". X. Chen, L. Xu, Y. Wang, H. Wang, F. Wang, X. Zeng, Q. Wang, J. Egger. J Biomed Inform., Elsevier, 55:124-31, June 2016. https://doi.org/10.1016/j.jbi.2015.04.003
- "**Inside-Out Instrument Tracking for Surgical Navigation in Augmented Reality**". C. Gsaxner, J. Li, A. Pepe, D. Schmalstieg, J. Egger. ACM Symposium on Virtual Reality Software and Technology (VRST), Article No.: 4, pp. 1-11, Dec. 2021. https://doi.org/10.1145/3489849.3489863
- "**Markerless Image-to-Face Registration for Untethered Augmented Reality in Head and Neck Surgery**". C. Gsaxner, A. Pepe, J. Wallner, D. Schmalstieg, J. Egger. MICCAI, Springer, pp. 236-244, Oct. 2019. https://doi.org/10.1007/978-3-030-32254-0_27

DC7	**Fostering interprofessional healthcare collaboration: an XR-enhanced pedagogical model for developing SRL/SSRL skills**
Host Institution	University of Oulu (UOULU)
Doctoral School	University of Oulu
Primary Supervisor	Prof. Dr Sanna S. Järvelä and Prof. Dr. Kristina Mikkonen
Applications platform	https://oulunyliopisto.varbi.com/what:job/jobID:764965/ Additional information contacts: sanna.jarvela@oulu.fi ; kristina.mikkonen@oulu.fi
Internal Deadline	31 December 2024
Planned duration	36 months
Subject Area	Learning sciences, educational psychology, nursing science, educational technology

Introduction:

This project aims to develop a pedagogical model using XR simulations to enhance interprofessional collaboration among nursing and medical students, focusing on self-regulated (SRL) and socially shared regulation of learning processes (SSRL). It combines multimodal data analysis, including physiological and qualitative measures, to evaluate XR's effectiveness in fostering interprofessional collaborative skills and improving communication in healthcare settings.

Objective:

Science Objectives: 1) To empirically study and evidence how XR simulations can be integrated into the pedagogical design to support nursing and medical students' interprofessional collaboration, focusing on their self and socially shared

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regulation skills (SSL/SSRL). 2) To analyse data from multiple sources, including physiological data such as heart-rate and electrodermal activity, motion tracking, and qualitative analysis of interactions to evaluate the effectiveness of XR simulations in supporting nursing and medical students' interprofessional collaboration. 3) To develop an SRL/SSRL theory guided pedagogical model for integrating XR simulations into medical and nursing students' training for effective interprofessional collaboration.
Training objectives: 1) Collect, pre-process, analyse, and interpret multimodal data to capture individual and collaborative learning processes. 2) Communicate findings to diverse audiences. 3) Understand current policies and regulations in the field, identify gaps and opportunities for improvement, and develop recommendations for policy makers based on their findings.

Expected Results: (R1) The empirically tested and innovative, SSRL-theory-guided pedagogical model created in this project will enable nursing and medical students to gradually develop their competence and stress management strategies through XR-enhanced interprofessional education. **(R2)** The developed solution can be integrated as an effective way to develop interprofessional collaboration skills in nursing or medical students and interprofessional education of health professionals already practising in the field, with the potential to tackle the hierarchy in healthcare teams to improve communication and teamwork.

Secondments: 1) 4 months at KUL (M18-21) to learn about educator dashboard for VR environment, assist with intervention study on collaborative problem-solving using VR simulation for clinical skills training in medical students. **2)** 4 months at UMINHO (M29-32) to learn about building AI support for learning in VR simulations, assist with data collection studies combining AI and VR.

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in learning sciences or related fields. Knowledge of self-regulated learning theories and technology enhanced learning, and a proven track record are required. Additionally, practical experience in multimodal data analysis and use of XR technology especially in the context of health sciences or nursing sciences will be a plus. The candidate should be familiar with basic techniques (e.g., basics of quantitative and qualitative methods). Candidates should be able to work in multicultural and multidisciplinary teams.

Recommended reading:

- Järvelä, S., Hadwin, A. F., Malmberg, J., & Miller, M. (2018). Contemporary perspectives of regulated learning in collaboration. In F. Fischer, C. E. Hmelo-Silver, P. Reimann, & S. R. Goldman (Eds.), *Handbook of the learning sciences* (pp. 127–136). Routledge.
- Mikkonen, K., Tomietto, M., Cicolini, G., Kaucic, B. M., Filej, B., Riklikiene, O., . . . Kaariainen, M. (2020). Development and testing of an evidence-based model of mentoring nursing students in clinical practice. Nurse Education Today, 85, 104272. doi:10.1016/j.nedt.2019.104272
- Järvelä, S. Dindar, M. Sobocinski, M., & Nguyen, A. (2022). Multimodal research for studying collaborative learning in higher education. In R. Sharpe, S. Bennett, & T. Varga-Atkins (Eds.), *Handbook for digital higher education* (pp. 199–210). Elgar.

DC8	**SurgiLearnX: Revolutionizing surgical training with XR-enhanced MOOC platform**
Host Institution	APOQLAR (APQ)
Doctoral School	University Hospital Essen
Primary Supervisor	Dr Daniela Salzmann
Secondary Supervisors	Prof. Dr. Jan Egger
Applications email	human.resources@apoqlar.com
Internal Deadline	15 December 2024

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Planned duration	36 months
Subject Area	XR-enhanced MOOC Platform development

Introduction:
Our objective is to define and develop a scalable surgical learning MOOC platform that adheres to eLearning design principles and meets the diverse needs of healthcare professionals as well as critical ethical considerations related to XR, AI, visualizations, and data protection. This includes creating structured XR teaching modules that leverage 3D medical objects, digital twins, and interactive case studies, while also evaluating the effectiveness of XR environments compared to conventional training methods. As a key contributor, you will gain hands-on experience in a Software-as-a-Service (SaaS) lifecycle, work collaboratively across disciplines, and explore market access strategies for XR technologies in healthcare education.

Objectives:
Science objectives: 1) To define the requirements of an open scalable surgical learning MOOC platform in XR for health professionals based on eLearning design principles and specific needs of the healthcare workers (e.g., adaptability to diverse student and instructor profiles, platform compatibility, collaboration, certification including legal and professional regulations compatibility, user management, scalable deployment, sustainable business model). 2) To develop a structured XR teaching module creation (for instructors) and consumption (for trainees) workflow to accommodate specific needs of surgical training (e.g., 3D medical objects, digital twins, case studies, animations, exercises, consultation). 3) To develop a study design to evaluate the effectiveness of medical and healthcare self-learning XR environments over conventional on-site trainings on training time, learning outcomes, retention of knowledge.
Training objectives: 1) Software-as-a-Service lifecycle (SaaS): Provide DCs with hands-on SaaS product experience, from ideation to market entry. 2) XR technology: Build proficiency in the development and design of XR applications that seamlessly work across multiple platforms and online services along with massive user and data management. 3) Interdisciplinary collaboration: Get familiar working effectively with experts from various fields to find solutions to complex problems. 4) Market access: Learn about research valorisation techniques and strategies for product marketing in the healthcare and XR technology sector.

Expected Results: The project anticipates the creation of a highly adaptable and scalable XR surgical learning platform catering to health professionals, promoting efficient training and skill development. It envisions the development of specialized surgical teaching modules enriched with immersive technologies and evaluations of their effectiveness in enhancing learning outcomes. Through interdisciplinary collaboration and market access strategies, the project aims to pave the way for innovative XR solutions in healthcare education and broaden access to these valuable training resources.

Secondments: (1) 3 months at UTW (M10-12) to gain insight on MOOC development, online learning and simulation training. **(2)** 3 months at TUG (M19-21) to enhance software skills for cross compatible XR platform and framework development. **(3)** 4 months at UGENT (M30-33) to conduct user tests for self-regulated learning techniques and refinement of the proposed solution.

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in biomedical engineering, technical medicine, computer science or a related discipline, with a strong interest or proven experience in XR technologies (VR, AR, MR) and their application in education or healthcare. They should have programming experience, particularly in C#, Unity, or Unreal Engine, with a background in developing XR applications. Experience in user experience (UX) design, conducting user tests, and refining user interfaces based on feedback is essential, along with a good command of both qualitative and quantitative research methodologies. Familiarity with the infrastructure for hosting MOOC applications—particularly cloud services, databases such as SQL and NoSQL, and user authentication systems—is highly desirable. Additionally, experience with web development frameworks such as React or Node.js, or backend infrastructure like AWS or Azure, would be advantageous. The candidate should also have strong research interests and analytical skills, with the ability to conduct rigorous academic work. The PhD will be enrolled in the doctoral school of the University Hospital Essen.

Recommended reading:

- **Remote proctorship program IHPBA** https://www.linkedin.com/posts/yujiagao-7a2117210_mixedrealityholomedicine-hololens2-activity-6993753622803091458-GjL9?utm_source=share&utm_medium=member_desktop 3)
- **Use of the mixed reality tool "VSI Patient Education" for more comprehensible and imaginable patient educations before epilepsy surgery and stereotactic implantation of DBS or stereo-EEG electrodes.**House, P.M., Pelzl, S., Furrer, S., Lanz, M., Simova, O., Voges, B., Stodieck, S.R.G., Brückner, K.E. Epilepsy Res. 2020 Jan;159:106247. Epub 2019 Nov 26. PMID: 31794952.

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- **Systems, Methods and Apparatus for Calculating Position and Rotation from a Manually set Reference Point in a Spatial Mesh**. Patent no: US2022392163A1 (05/2023)
- I**mage Registration with Semantic Segmentation Mask. Ensure results for 3D Visualisation**.Patent no: 19196193.7 (09/2019)

DC9	**Revolutionizing healthcare training: innovative performance monitoring to support error-recovery in simulation-based psychomotor skills training**
Doctoral School	University of Twente (UTW)
Doctoral School	University of Twente
Primary Supervisor	Dr Marleen Groenier
Application Platform	https://utwentecareers.nl/ Additional information contact: m.groenier@utwente.nl
Internal Deadline	15 December 2024
Planned duration	36 months
Subject Area	Educational psychology

Introduction:
The project aims to enhance performance monitoring of health professionals during technical medical interventions, such as bronchoscopy or thoracic surgery. For this, motion and vital sign sensors and mixed reality technology will provide continuous and objective performance feedback. Emphasis will be placed on identifying effective error-recovery strategies as these are essential for patient safety and professional development of health trainees. Continuous performance monitoring will enable detection of subtle and quick changes in a learner's skill acquisition process. This will lead to a more comprehensive understanding of the learning process, of factors affecting performance and of the trainees' abilities, experiencing what it means to patients and them to make mistakes, allowing for more targeted feedback and training. The performance assessment needs to take place without disrupting the tasks being performed in order to obtain more natural and representative performance data. The multimodal approach combines knowledge from various fields, including medicine, technology, and data analysis.

Objectives:
Science objectives: 1) To develop and validate a multimodal performance monitoring system for continuous and objective feedback and assessment of psychomotor skill acquisition in a simulation-based learning environment. 2) To develop a taxonomy of error-recovery strategies based on effectiveness, adaptability and impact on patient safety that is implemented in the performance monitoring system.
Training objectives: 1) Communication and teamwork in an interdisciplinary educational setting. 2) Working with the FAIR principles. 3) Developing technology-enhanced learning environments for skill training and assessment).

Expected Results: R1: Innovative continuous monitoring system, incl. motion sensors, open-source software and user manual, for improved training and assessment of health professionals; **R2:** fostering objective evaluation of the training and the use of meaningful and reliable data and their combination with expert judgement where needed. **R3:** This will make training more accessible and cost-effective and enhance patient safety by identifying and correcting errors.

Secondments: (1) 3 months at UKE (M13-15) for first testing of multimodal measurement of psychomotor skills acquisition**; (2)** 2 months at APQ (M22-23) to measure error-recovery strategies in a surgical simulation; **(3)** 3 months at UGENT (M31-33) to evaluate multimodal performance monitoring system with end-users.

Project-specific selection criteria: Candidates should have a Master's degree or similar education level in biomedical engineering, technical medicine, psychology, educational sciences or a related discipline, with knowledge of simulation- and sensor-based performance monitoring and assessment. A proven track record is required. Additionally, practical experience in (AI) programming and/or educational design in healthcare will be a plus. The candidate should be familiar with basic techniques (e.g., statistical analyses, qualitative data analysis). Candidates should be familiar with data collection and analysis using educational technology, simulation and/or sensor technology.

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Recommended reading:

- **Objective and automated assessment of surgical technical skills with IoT systems: A systematic literature review**. Castillo-Segura, P., Fernández-Panadero, C., Alario-Hoyos, C., Muñoz-Merino, P. J., & Kloos, C. D. (2021)*Artificial Intelligence in Medicine*, *112*, 102007.
- **Error tolerance: an evaluation of residents' repeated motor coordination errors.** Law, K. E., Gwillim, E. C., Ray, R. D., D'Angelo, A. L. D., Cohen, E. R., Fiers, R. M., ... & Pugh, C. M. (2016). *The American Journal of Surgery*, *212*(4), 609-614.
- **Performance assessment using sensor technolog**y. Mohamadipanah, H., Wise, B., Witt, A., Goll, C., Yang, S., Perumalla, C., ... & Pugh, C. (2021). *Journal of surgical oncology*, *124*(2), 200-215.

DC10	**Mixed Reality with both visual perception and manual interaction to understand and learn complex assembled structures for anatomy learning and clinical tasks training**
Host Institution	University of Pisa (UPI)
Doctoral School	University of Pisa
Primary Supervisor	Prof. Dr. Vincenzo Ferrari
Email address for applications	vincenzo.ferrari@unipi.it
Internal Deadline	15 December 2024
Planned duration	36 months
Subject Area	Biomedical Engineering, Computer Science

Introduction:
VR and AR applications would greatly benefit from virtual objects that can be touched, pushed, lifted, moved etc., which is closely analogous to how we commonly interact with real objects. Thus far, even though scientists have demonstrated the behavioural benefits of having haptic interfaces that reproduce how humans interact with the world and communicate ideas, commercially available haptic interfaces and applications are at present are mainly suitable for VR and not for AR applications, as they do not allow natural grasping and they occlude the real environment. Rather, the ideal tactile interface for AR should provide the following: it should offer a realistic contact sensation; it should not affect users' ability to grasp and manipulate real objects; it should not contribute to visual occlusions of the real environment due to the interface itself.
This will allow users to take full advantage of the potential offered by an interactive AR environment that allows them to explore by sight and touch 3D models, easily acquiring for example complete knowledge of anatomical districts of interest and the spatial relationships between the anatomical structures involved.

Objectives:
Science objectives: 1) To develop Mixed Reality technologies and methodologies, focusing on the integration of AR with manual interaction, that can help learners achieve a better 3D understanding of complex assembled objects – such as anatomical structures. 2) To evaluate the potential of commercially available haptic/force feedback gloves to improve the understanding of assembled objects under MR, combining visual cues and manual interaction.
Training objectives: 1) haptic/force feedback gloves specifications, potentialities and software integration. 2) haptic cues to perceive and recognise 3D geometry and assembled objects.).

Expected Results: R1: State-of-the-art on the knowledge, prototypes and experimental studies of MR with manual interaction and its potential for application in medical and healthcare education to improve the understanding of complex assembled structures. **R2:** Implementation, testing, and validation of a training platform that offers the learner (e.g. student or health professional) the possibility to naturally manipulate virtual objects. **R3:** Evaluate if the implemented platform can improve the learning efficiency thanks to the enhanced perception involving not only visual cues but also touch and kinaesthetic information by MS and IS.

Secondments: (1) 2 months at TUG (M10-11) to focus on Unity programming and Hololens apps development; **(2)** 4 months at UBC (M17-20) to focus on psychological and technical SoA on haptic cues to perceive and recognise 3D

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geometry of assembled anatomical structures; **(3)** 2 months at UKE (M35-36) to focus on platform final phase validation for anatomy learning.
Project-specific selection criteria: Candidates should have a Master's degree or similar education level in Biomedical Engineering or Computer Science Knowledge of Computer Graphics programming, and a proven track record are required. Additionally, practical experience in Augmented/Mixed Reality and/or Haptics applications development using Unity 3D game engine or similar and Computer Vision will be a plus. The candidate should be familiar with basic techniques about applications design, implementation and testing. Candidates should be familiar with human computer interaction modalities both from a technical and ergonomics view point.
Recommended reading: ● **"Can virtual reality improve traditional anatomy education programmes? A mixed-methods study on the use of a 3D skull model,"** S. Chen, J. Zhu, C. Cheng, Z. Pan, L. Liu, J. Du*, et al.*, *BMC medical education,* vol. 20, pp. 1-10, 2020. DOI https://doi.org/10.1186/s12909-020-02255-6 ● **"Tactile augmented reality for arteries palpation in open surgery training,"** pp. 186-197. S. Condino, R. M. Viglialoro, S. Fani, M. Bianchi, L. Morelli, M. Ferrari*, et al.*, DOI https://doi.org/10.1007/978-3-319-43775-0_17 ● **"A wearable fabric-based display for haptic multi-cue delivery,"** pp. 277-283.M. Bianchi, E. Battaglia, M. Poggiani, S. Ciotti, and A. Bicchi, DOI 10.1109/HAPTICS.2016.7463190

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