Immersive Game Technologies for Innovative Education - A Method for Experimental Interdisciplinary Technology Transfer

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Abstract. Immersive, sensor-enabled technologies such as augmented and virtual reality expand the way human beings interact with computers significantly. While these technologies are widely explored in entertainment games, they also offer possibilities for educational use. However, their uptake in education is so far very limited. Within the ImTech4Ed project, we aim at systematically exploring the power of interdisciplinary, international hackathons as a novel method to create immersive educational game prototypes and as a means to transfer these innovative technical prototypes into educational use. To achieve this, we bring together game design and development, where immersive and interactive solutions are designed and developed; computer science, where the technological foundations for immersive technologies and for scalable architectures for these are created; and teacher education, where future teachers are educated. This article reports on the concept and design of these hackathons.

Keywords: Immersive Technologies · Educational Games · Hackathons.

1 Introduction

According to a recent EU report 43% of European Citizens are lacking critical digital competencies while 90% of the professions in near future will require digital competencies. Therefore, an urgent need for the 71 millions of EU students and 5.7 millions of EU Teachers to increase their digital skills via better education, arises [5]. However, innovation processes for technology enhanced learning are not yet well-prepared for disruptive innovation and require novel approaches of development and technology-transfer [9].

A huge obstacle in the uptake of advanced technological solutions (such as serious games, augmented and virtual reality) in schools on primary and secondary level, is that generally, teacher education does not contain the concepts of conceptualising, designing, and applying such solutions to the extent required (though there are exceptions such as [4]).

At the same time, the increasingly available study programmes for game designers and game developers only begin to take educational games and advanced

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educational technologies into account [14]. Currently, those programmes lack the theoretical underpinning of pedagogic and didactic theories to contribute to the development of educational technologies more substantially. Likewise, computer science education mostly focuses on the technical aspects of solutions with too little attention to design aspects and pedagogical underpinnings. However, subdomains in computer science education such as Human-Computer Interaction or Digital Learning may focus more on these aspects to ensure a better learning outcome.

We believe, that technology-innovation procedures and interdisciplinary ways of designing and developing new systems as explored in novel fields such as game design and games-technology research can be beneficial to the development of innovative, immersive educational technologies. Consequently, here we report on the progress achieved in the ImTech4Ed project (Immersive Technologies for Education), where we aim at exploring such novel ways of technology innovation for education based on experiences in utilising interdisciplinary methods of game design and development.

2 Related Work

Research suggests that teachers have difficulties developing comfort with technology [3] while many teachers are pessimistic and skeptical with immersive technologies [17]. Even future teachers (e.g. pre-service teachers) recognize that immersive technologies are highly motivating, engaging, and able to support students better, still have concerns about their use and implementation. Many of them feel inexperienced in using such technologies [6] or find the available tools difficult, especially at the beginning [7]. In addition, teachers may also need to design, model and program immersive activities, however, there is little support in creating mixed reality education spaces [8].

Immersive Education is a method that utilizes a simulated environment in which the learners can be completely immersed in the learning process/task and moving beyond the mere use of virtual worlds to become more embedded into the physical world around us. Literature on the convergence of the technical, pedagogical and cognitive components and interactions within immersive environments is scarce, and past attempts fall short of fully describing the affordances of augmented and mixed reality, though [1] provides a first approach of mapping learning activities to specific game mechanics, [19] provides a more general approach of using game mechanics for encoding and presenting knowledge in a serious game, and [21] discusses the advantages of learning in an embodied immersive virtual environment. ImTech4Ed builds on these and provides a Pedagogical Framework for building Immersive Environments filling in the current blank. Finally, the importance of augmented reality (AR) and virtual reality (VR) games is high. AR and VR games elicit players' cognitive and affective responses in different ways, where technological, pedagogical and evidence-based findings for AR and VR are discussed in [2, 10, 24]. Collaborative games increase

cognitive involvement in solving problems, which leads to enjoyment, pleasure and confidence among users [23].

Recent approaches in the relatively new interdisciplinary game design educational programmes for bachelor and master students successfully demonstrate the value of interdisciplinary education and problem-based learning [14] for cross disciplinary collaboration of programmers, designers, and artists. ImTech4Ed builds on such insights and aims at taking this approach one step further by connecting to educational science and computer science and extending to international and cross institutional scope. At the core of this project is the interdisciplinary collaboration of students from connected disciplines aiming at lowering barriers for interdisciplinary thinking and understanding. In line with our approach, [25] explore the technologies that can be used in curricula to make education "smarter" and more adaptive in order to better meet the needs of today's learners. The main emphasis is placed on the theory and best practices of incorporating emerging technologies into curricula so as to educate learners in the 21st century. Adding to these findings, ImTech4Ed aims at examining, which pedagogical aspects are most suitable for integrating emerging technologies. Consequently, it will potentially help educators and stakeholders design and implement curricula that effectively prepare learners for the challenges of tomorrow.

3 Methodological Approach

Our approach builds upon interdisciplinary and international cooperation among different connected higher education institutions to create quick, student-driven, creative hackathons as initiator for immersive educational technologies to be prototyped and further developed towards educational assets. It is connected to the principles of co-creation [11], which brings together various stakeholder groups in innovation processes as well as participatory design [22], which allows for an iterative, prototyping-based development process involving designers and stakeholders. Our approach goes beyond these by not only connecting designers/developers to stakeholders but at the same time connecting multiple educational disciplines and adding the explicit goal of educating future stakeholders by preparing them for innovation.

Four pillars represent the fundamental of our approach, which aim at defining a stable method towards the reproducible, creative, and innovative development of immersive prototypes.

1. *Methodological Guidelines* provide the technological and didactical context for the development of prototypes.
2. The *Authoring Technology Framework* aim at bridging the gap between non-technical didactic staff and technical developers.
3. *Experimental Hackathons* are the core interdisciplinary, experimental and explorative development activity towards the fast creation of innovative immersive prototypes.

4. *Application and Evaluation* provide a quality approval and selection mechanism to ensure applicability and educational potential of immersive prototypes.

With these pillars, we aim at addressing the identified gaps: teachers need to be better informed about the use of immersive technology (methodological guidelines); technologies need to be suited to the technological competencies of teachers (authoring technology framework); and interdisciplinarity and practical application need to be explored in education (experimental hackathons). With the application and evaluation step, evidence will be generated about the feasibility of this approach. Short project cycles aligned to human-centered design processes ensure the possibility to quickly react to feedback; the interdisciplinary collaboration ensures that relevant perspectives are considered.

3.1 Methodological Guidelines

The methodological guidelines are developed based on best practice experiences and a literature study. These guidelines aim at providing practical support for the use of immersive technologies for learning. They constitute an inquiry-based pedagogical approach for university students and secondary school in-service teachers, which takes technological and didactic constraints as well as diversity and accessibility issues into account. The guidelines provide a framework for developers and educators, in order to create immersive game prototypes making appropriate use of augmented and virtual reality and other immersive technologies.

In particular, the guidelines combine traditional instructional activities with AR/VR experiences within digital games. The methodological guidelines outline the pedagogical and didactic approach to support game-based, immersive education.

3.2 Authoring Technology Framework

Innovative immersive technologies require advanced authoring and development environments to produce high quality outputs. However, most of these environments and tools target specialized professional developers and users, limiting their applicability in educational non-technical contexts. At the same time, tools applicable by non-technical users often miss the flexibility and complexity required for innovative technological solutions.

The authoring technology framework bridges this gap by mapping authoring tools and development environments to process steps and requirements. The authoring technology framework thus connects the methodological guidelines, which represent the didactic view on immersive solutions to the technical tools available to implement these. It is therefore based on a technology survey of available tools and platforms and maps these to the methodological and didactic aspects of implementing immersive solutions.

3.3 Experimental Hackathons

"A hackathon is a highly engaging, continuous event in which people in small groups produce working software prototypes in a limited amount of time" [15]. Hackathons are established in many interdisciplinary domains as a means to quickly develop experimental, innovative prototypes [12]. Recently, hackathons have also been explored for their educational potential [16, 18].

Within the ImTech4Ed project, we aim at combining both aspects of the hackathons: their potential for technological innovation as well as their interdisciplinary educational potential. To do so, we organise the hackathons as multi-location, interdisciplinary events, which bring together educators and students from game design and development, computer science, and educational sciences. Interdisciplinary teams compiled of students from the different disciplines collaborate within these hackathons intensively over a period of four days.

Immersive prototypes are the result of fast paced short cycled development actions with small teams working on very focused small-scale prototypes solving a concrete problem:

- Fast-paced development cycles lead to quick solutions and fast feedback cycles allowing us to quickly react to feedback without risking long development periods to be wasted.
- Developing small-scale immersive prototypes allow to experimentally explore a range of different educational and technological aspects, rather than focusing on very few. This gives also the desired flexibility to choose from a selection of prototypes those that seem promising for further development into educational practice.
- While prototypes developed in this fast-paced way cannot be expected to be at production level quality immediately, the approach to work towards several of these prototypes in parallel fosters creativity, interdisciplinary collaboration, and an open-minded development approach.

3.4 Application and Evaluation

The application and evaluation aspect of the outcomes of the hackathons is done for two purposes: (1) to evaluate prototypes for their potential contribution to education, and (2) to inform members of the target group (i.e. teachers and pre-service teachers), who get involved into the evaluation procedure about the innovation that can be achieved with these prototypes and to educate them on possible use cases.

Consequently, the evaluation represents an important step to ensure applicability, usability, potential, and quality of the immersive prototypes and concepts. The prototypes will be tested and evaluated by various means, comprising their conceptual and technical evaluation by technological experts, their domain-related assessment by educational experts as well as their application in educational contexts by educators and learners.

Prototypes with a positive evaluation are selected for further development in subsequent project phases to increase functional completeness, stability and scalability. Furthermore, since (pre-service) teachers are involved into the evaluation procedure, it also supports the transfer of knowledge, experience, and technology from the development teams into the educational domain by involving educators and learners in the evaluation process.

4 Expected Results, Limitations, and Conclusion

4.1 Expected Results

ImTech4Ed aims at delivering its methodological guidelines together with a set of immersive educational prototypes evaluated in educational practice. The direct impact of ImTech4Ed is expected to be on participating students, pupils, teachers, educators, and researchers in broadening their view and understanding of interdisciplinary approaches and collaborative international work towards the creation of immersive educational technologies. However, ImTech4Ed aims at impacting innovation processes in the development and creation of innovative educational technologies with this multidisciplinary methodology.

With the integration of educational processes into the design and development methodology of ImTech4Ed we expect to be able to address issues of technology acceptance early on in the education of future educators. Likewise, interdisciplinary thinking increases media competence of future educators by being involved in conceptual and technological development of educational prototypes. As stated in the introduction, the lack of technological aspects in teacher education is among the obstacles to the uptake of these innovative technologies in practical education. We expect, that interdisciplinary approaches such as envisioned by ImTech4Ed help to lower these barriers.

4.2 Limitations

The ImTech4Ed project is still in an early development phase. Currently, the conceptual framework as outlined throughout section 3 is designed and planned. The first ImTech4Ed hackathon is planned and will be performed in late Spring 2021. However, due to the COVID-19 situation, the project consortium had to deviate from original plans especially with respect to the organisation of hackathons, which caused delays and changed constellations. We expect that hackathons performed in an online-only manner might negatively impact the intensiveness of team collaborations.

4.3 Conclusions

While still in early phases, the ImTech4Ed project already provides an innovative methodology towards the creative and innovative creation of immersive educational prototypes and solutions that will potentially help teachers, to increase the use of immersive technologies in education. With this methodology,

ImTech4Ed aims at bridging the gap between advanced innovations in immersive game technologies and their slow uptake in educational practice.

The interdisciplinary, iterative approach based on methodological guidelines, authoring technology framework, experimental hackathons, and application and evaluation furthermore aims at being reproducible and reusable across various educational contexts. The long-term benefit is expected to go beyond the direct outputs: interdisciplinary thinking towards the envisioning, design, and creation of immersive educational technologies aims at improving the way these technologies are created and brought into educational practice in a sustainable way.

Acknowledgements The ImTech4Ed project is funded under grant agreement number 2020-1-DE01-KA203-005679 as a strategic partnership for higher education.

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