Blended Realities - Higher Education Student Reflections on Acquiring Skills for Game Creation in a Project-Based- and Blended Learning Environment

ADAM PALMQUIST, Division of Journalism and Creative Media, HABIT Research Group, Nord University, Levanger, Norway and Department of Applied Information Technology, University of Gothenburg, Gothenburg, Sweden
JOANA ALVES, 2Ai, School of Technology, Polytechnic of Cávado and Ave (IPCA), Barcelos, Portugal
RENE BARANYI, Faculty of Informatics; Research Group for Industrial Software (INSO), TU Wien University, Wien, Austria
ROBIN MUNKVOLD, Division of Journalism and Creative Media, Nord University, Levanger, Norway
VÍTOR CARVALHO, 2Ai Laboratory, School of Technology, Polytechnic of Cávado and Ave (IPCA), Barcelos, Portugal
EVA OLIVEIRA, 2Ai Laboratory, School of Technology, Polytechnic of Cávado and Ave (IPCA), Barcelos, Portugal

This study delves into higher education students' active participation in an Erasmus+ blended intensive program (BIP) that focuses on teaching game creation. Three universities facilitated the BIP, which had 22 international students. The program, designed around project-based learning and onsite/online collaboration, empowered students to better prepare them for careers in the game industry. Two student focus groups were analyzed using thematic analysis to understand the students' perceptions of the educational approach. The investigation findings emphasize that aligning game creation teaching with conditions and technologies in the game industry is challenging in practice despite its apparent simplicity on paper. It also underscores the crucial role of soft skills and transversal competencies in game creation education. These skills, often overlooked, play a vital role in the success of game creation projects. With this study, we wish to contribute to the discourse on game education by offering insights into the enablers and barriers to teaching game creation within higher education. It provides ten useful considerations for game scholars and educators to deliberate in their profession.

Adam Palmquist & Robin Munkvold work declare no conflict of interest. We extend our gratitude to the Erasmus+ program for partially funding the study's underpinnings, enabling us to conduct this investigation. Authors One and Three acknowledge EXCITED – Centre for Excellent IT Education for partially funding their devoted time conducting the investigation.

Authors' Contact Information: Adam Palmquist, Division of Journalism and Creative Media, HABIT Research Group, Nord University, Levanger, Norway and Department of Applied Information Technology, University of Gothenburg, Gothenburg, Sweden; email: adam.palmquist@nord.no; Joana Alves, 2Ai, School of Technology, Polytechnic of Cávado and Ave (IPCA), Barcelos, Portugal; e-mail: a19428@alunos.ipca.pt; Rene Baranyi, Faculty of Informatics; Research Group for Industrial Software (INSO), TU Wien University, Wien, Austria; e-mail: rene.baranyi@inso.tuwien.ac.at; Robin Munkvold, Division of Journalism and Creative Media, Nord University, Levanger, Norway; e-mail: robin.munkvold@nord.no; Vítor Carvalho, 2Ai Laboratory, School of Technology, Polytechnic of Cávado and Ave (IPCA), Barcelos, Portugal; e-mail: vcarvalho@ipca.pt; Eva Oliveira, 2Ai Laboratory, School of Technology, Polytechnic of Cávado and Ave (IPCA), Barcelos, Portugal; e-mail: eoliveira@ipca.pt.

This work is licensed under a Creative Commons Attribution International 4.0 License.

© 2024 Copyright held by the owner/author(s).
ACM 2832-5516/2024/12-ART2
https://doi.org/10.1145/3704414

CCS Concepts: • **Applied computing → Collaborative learning**; **Interactive learning environments;** • **Human-centered computing → Virtual reality**;

Additional Key Words and Phrases: Higher Education, Game development teaching, Virtual reality (VR) teaching, Collaborative learning environments, Soft and Hard Skills, Transversal competencies for game development, Erasmus+, Blended Intensive Program (BIP), Game creation curriculum, Game Industry Technology integration in higher education, Project-based learning environment, Blended learning environment

ACM Reference Format:
Adam Palmquist, Joana Alves, Rene Baranyi, Robin Munkvold, Vítor Carvalho, and Eva Oliveira. 2024. Blended Realities - Higher Education Student Reflections on Acquiring Skills for Game Creation in a Project-Based- and Blended Learning Environment. *ACM Games* 3, 1, Article 2 (December 2024), 26 pages. https://doi.org/10.1145/3704414

1 Introduction

The game industry, a pioneer in the digital sector and one of the largest globally, is currently undergoing several disruptions. Reports on the European game industry and scientific game journals have emphasized that the most critical challenges for the gaming industry are related to technology, business models, and recruitable talent [14, 16, 33]. The identified shortage of talent represents a bottleneck for the industry's growth [16, 33]. Professional game education is vital for cultivating the next generation of game talent, ensuring they are informed about opportunities and potential careers in the gaming industry [16, 33].

However, in their game industry report, Hiltunen et al. highlight the lack of essential game-creation skills among Europe's current pool of game talent [16]. They note a discrepancy between the skills and competencies gained in European game education programs and those required by the game industry. According to Hiltunen et al. the contemporary game industry encompasses more than traditional areas like game design, graphics, and programming [16]. While technical skills have traditionally been and continue to be important in the game industry, there is a growing demand for communication, collaboration, critical thinking, and similar soft skills. Soft skills are essential for game industry success, benefiting employees [33] and organizations [16]. The disparity between the game-creation talent delivered by educational institutions and the talent the industry demands suggests that some European game education providers and associated researchers have not entirely realized the evolution of the skills and abilities needed for a career in this field. It has been argued that the game studies community primarily focuses on analyzing games, players, and gameplay as a social phenomenon [26].

However, this body of knowledge typically does not prioritize exploring game development processes, even less how to teach them. Engström states:

> *"Given the large number of game development programmes offered by universities (mainly in the west), this is an important observation. Many game scholars have a background in game analysis, but this does not automatically transfer to an understanding of how to create games."* [12:78]

Although many higher education teachers involved in game creation instruction may have backgrounds in related fields such as computer sciences, social science, media, and game studies, among others [12, 27], possessing this type of expertise does not automatically translate into a comprehensive understanding of the game creation process, nor does it necessarily give proficiency in teaching game creation. Therefore, it seems reasonable to conduct research on,

evaluate the current, and identify novel, scholarly approaches to game education. Such endeavors could contribute to preparing and equipping students aiming for a career in game creation with the proper knowledge, skills, and competency.

Against this illustrious backdrop stands an Erasmus+ **Blended Intensive Program (BIP)** covering **virtual reality (VR)** game creation as our object under scrutiny. The BIP was jointly coordinated by the institutions Polytechnic of Cávado and Ave, Portugal, Nord University, Norway, and TU Wien, Austria.

The Erasmus+ Program Guide defines BIPs as *'short, intensive programmes that use innovative ways of learning and teaching, including the use of online cooperation. The programmes may include challenge-based learning where transnational and transdisciplinary teams work together to tackle challenges'* [9:52]. The BIP learning design integrates a minor physical component (5-30 days) with a major virtual component. A BIP must involve at least three higher education institutions from different EU Member States collaborating to create and jointly deliver the programs, which must provide a minimum of 3 ECTS credits for the participating students [36]. The BIP initiative seeks to facilitate increased collaborative learning across borders and disciplines by integrating learners from various EU countries. The concept is to promote accessibility for students of diverse (academic) backgrounds through flexible physical mobility durations and the employment of innovative educational approaches such as online/onsite collaboration [9] and active learning techniques [29].

BIPs frequently practice **project-based learning (PBL)** environments, wherein transnational and transdisciplinary student teams collaborate using their diverse skillsets to solve challenges posed by regions, industries, or companies [36]. Through this, the BIP aims to foster a practical, hands-on learning experience, encouraging students to apply theoretical knowledge to real-world problems, thereby enhancing their problem-solving and teamwork capabilities [9]. By simulating real-world work environments and connecting higher education knowledge with industry practice, a BIP promotes participants' employability, social awareness, networking, civic engagement, innovation, and sustainability [9].

The BIP implementation guide states further that the initiative's ambition includes exposing students to diverse perspectives, methods, and practices encountered in industry and work-life contexts [8]. A BIP design should cultivate students' transversal skills such as collaboration, communication, critical thinking, digital literacy, resilience, and adaptability [8]. Moreover, the programmers should emphasize fostering student's personal and professional growth through applied experiences, expanding contextual knowledge, and offering networking opportunities, preparing students for their careers [8].

This paper explores the perceptions and insights of students who participated in the BIP focusing on VR game creation. The analyzed data originate from two focus group discussions held on separate occasions approximately one week after the BIP course was completed and the student's project was concluded. The primary aim of this study is to uncover the factors that shaped students' views on the course and to conduct an in-depth examination of how these elements either supported or hindered the execution and outcomes of the BIP. The following **research question (RQ)** has guided our exploratory investigation:

- RQ: How do higher education students discuss and perceive retaining digital game creation skills through project-based activities within a blended learning environment?

With our study, we seek to contribute to an in-depth understanding of how to conduct game education by offering insights into practical strategies for teaching and instructing game creation within higher education. This endeavor aligns with the research findings and recent game industry reports, aiming to bridge the gap between academic preparation and industry expectations.

1.1 Theoretical Framework

This study employs an analytical framework grounded in Active Learning principles and investigates students' perceptions of participating in an Erasmus+ BIP on game creation. The framework aims to elucidate students' perceptions concerning the demands of the contemporary game industry, the reviewed corpus of research, and the specific objectives underpinning BIPs. Through this examination, we aim to enhance the understanding of how game education can be conducted within higher education learning environments, focusing on the practical application of teaching game creation skills.

1.1.1 Active- and Project-based Learning. 'Active Learning' has been defined in various ways in the literature, depending on the context and field. The theoretical foundation and methodological goal of active learning is to equip students with the tools necessary to take charge of their development. This is achieved by engaging them in meaningful challenges necessitating reflection and higher-order thinking skills such as analysis, synthesis, and evaluation. It also considers the involvement of a diverse student cohort and the leveraging of appropriate technologies within the learning environment [29]. Active Learning involves learners engaging in meaningful activities and tasks that encourage them to apply and transfer knowledge more effectively, potentially enhancing metacognitive and self-regulation skills [40]. The theoretical foundation of active learning is rooted in constructivism, which views knowledge as being constructed gradually based on its congruence with students' prior experiences [29]. Consequently, like multiple constructivist approaches to how learning transpires, active learning emphasizes the importance of learners' sense-making and interpretation of the learning environment and content. Since the early 2000s, active learning approaches have been increasingly adopted in higher education, especially in the applied sciences, such as engineering [11, 29]. Active learning stands in contrast to more traditional teaching methodologies, such as auditorium lectures, where the teacher acts as an active transmitter of information, and students are passive recipients of knowledge [29]. They believe that students should not merely passively acquire knowledge but should be encouraged to acquire competencies and skills actively. Active learning community argues that to ensure students gain applicable skills rather than superficial knowledge, they must be invested, willing to contribute, and actively participate in the learning environment and educational activities [29].

Active learning enfolds the blended learning practice, intending to create a resilient, engaging, yet resource-efficient learning environment that leverages the strengths of both traditional and digital instructional methods [29]. Blended learning generates a multifaceted educational encounter that provides students flexibility, accessibility, and personalized learning, expanding access to education across diverse populations [25]. Blended learning amalgamates the onsite and the online settings, creating a learning environment that facilitates self-directed and collaborative skill acquisitions [4] whilst using a variety of communication channels [17] among students, educators, and external industry stakeholders, serving in capacities such as clients, mentors, and industry supervisors [49].

One of the active learning strategies is PBL [29]. PBL has its roots in experiential learning, which is the fundamental principle that students learn better when they participate actively in open learning experiences rather than passively in structured activities. In this sense, PBL offers opportunities for students to apply what they learn in real situations where they face problems, discover and test solutions and interact with other students within a specific and close-up context [40]. Proponents of PBL contend that acquiring knowledge through its natural application aids learners in positioning this knowledge within an epistemological category [11]. Consequently, empowering learners to perceive their newly acquired knowledge as a practical tool for problem-solving [1]. PBL underscores the importance of teamwork in addressing societal

or industry-relevant issues, bridging theoretical knowledge with practical application [11]. The PBL approach is characterized by its learner-centered methodology, allowing students to engage with real-world scenarios reflective of their future professional contexts [11]. The PBL methodology has faced criticism across various research domains. A prevalent critique concerns skills acquisition through project participation - doing does not necessarily equate to learning. For skills to evolve and form part of an individual's stable procedural knowledge base, reflection and cognitive processes must occur within the learner [47]. PBL has been criticized for mandating that students already have specific competencies - otherwise, they need to acquire them - before committing to comprehending the skill(s) the learning moment intends [45]. This makes it ambiguous for students to understand whether the primary learning objective is mastering the PBL format or the subject matter in the learning environment [45].

Furthermore, PBL has been criticized for the difficulty teachers face in accurately determining whether a student has acquired a specific skill which the learning environment intended, given the multitude of variables at play during a project [1]. Moreover, the essence of a skill may be abstract, potentially lacking direct applicability or relevance to real-world project scenarios, rendering the skill challenging to apply directly. Nonetheless, this does not detract from the skill's importance [11].

2 Related Work

2.1 Teaching Game Creation in Higher Education

The knowledge on how to educate university students in game creation is scant, with limited attempts to synthesize outcomes from best practices to create research-informed advice for game educators [52]. Previous works are mainly case studies revealing an emphasis on active learning techniques. PBL approaches have been indicated to facilitate game students' development of transversal competencies, actionable skills, and techniques valuable in solving technical problems [20, 30, 43, 46, 53]. PBL approaches to teaching game creation also stress the importance of inviting professionals from game organizations as guest lecturers and employing industry technology [3, 30]; such approaches, especially inviting industry actors, have been shown to enhance game student course engagement [20]. The potential of PBL in game education has been argued valuable, stressing the importance of team collaboration and role-specific learning in mirroring real-world game creation dynamics [43, 46, 53].

Aligning higher education courses curriculum for game creation with game industry conditions seems to be a favorable aspect in several studies arguing for PBL approaches, as they supposedly provide a practical, skill-oriented learning environment appropriate for manifold game industry stakeholders [20, 30, 46]. Moreover, Yun et al. [53] argue that project-based game development studies benefit from multidisciplinary course design encompassing computer science, art, game design, production, and business.

Student teamwork and project-based game creation, combined with collaboration between universities and industry, seem to be the foundational elements for game students' learning environments in higher education, at least according to published sources. The rationale for the prevalence of these elements in game education seems to be their ability to mimic real-world settings.

It has been implied that game educators in higher education utilizing PBL conditions stand to gain by integrating established game-specific production frameworks, such as the **International Game Developers Association (IGDA)** Curriculum, rather than more generic software development frameworks [28, 30]. Game development frameworks delineate processes recognized by various stakeholders as necessary for simulating real-world game development for game students. In contrast, conventional software development frameworks may fail to capture game creation's distinctive characteristics and essential aspects [28, 30].

A proposed strategy for enabling new game students originating from traditionally assorted disciplines to better understand the elements and frames of game creation is to create comprehensive introductory courses covering the fundamental aspects of game creation, such as design, programming, and visual art, and how these aspects need to work together for a successful game creation process [13, 39]. Such initiatives have the potential to effectively immerse game students into the multidisciplinary circumstances that encompass digital game production, have the potential to enhance their understanding, and aid their forthcoming course collaborations while laying a vital piece of groundwork towards their professional growth and development [13, 39].

As peer-reviewed literature on approaches to conducting game education have been scant, we decided to examine the available research focusing on game development/production in a real-world context, which also turned out to be a relatively underexplored field.

2.1.1 Game Creation in Real-world Settings. According to Martin [27], Marklund et al. [26], and Engström [12], the processes behind the creation of games in real-world settings have garnered scant attention within the broader scope of game research with the concept of game design as a distinguished activity. Currently, the existing body of knowledge on game creation is dominated by practitioner publications [6, 7]), which often provide valuable insights into current game industry practices and trends. However, although game practitioner publications might have a substantial empirical foundation, they may lack the rigorous methodological approaches, theoretical frameworks, and empirical validation required of the research community. This can lead to a reliance on anecdotal evidence and personal experience rather than systematic analysis and peer-reviewed findings.

Some academic investigations have occurred on how to create games in real-world settings. Styhre conducted a longitudinal ethnography on indie game developers in Sweden and described game development as an innovation-driven field that intersects computer science, digital media, and entertainment [44]. He emphasizes the value of entrepreneurial skills encompassing understanding digital media, proficiency in game-creation technologies, and engaging in global digital channels to connect with local gaming communities and distribute the product [44]. Moreover, O'Donnell has made several contributions to game creation research, grounding his findings in ethnographic research in real-world settings of game development and underlining the critical role of technological tools in the game industry [34]. The importance of understanding and mastering these tools is a part of the game-creation process [34], which also has been recognized in additional studies by other researchers [10, 48, 51]. Moreover, Whitson has explored how tools facilitate collaboration across various disciplines within game development, emphasizing their importance in interdisciplinary cooperation, constituting a cornerstone in game creation [50].

Jørgensen's case study of a novel game startup with limited game creation experience showed that their creation was hindered by the team's inexperience in game design and development process, underlining the challenges associated with a lack of relevant understanding of how game production functions [21]. In another study in the game startup environment, Palmquist interviewed experienced game designers and developers working with marketing games, serious games and gamification, seeking their attitudes and opinions on working with a diverse client base and their software products [37]. The paper suggests that designers and developers view their work processes as distinct from those in the software industry [37]. Findings, like those from Palmquist [37] and Jørgensen [21], have been indicated in other studies [15, 32]. The academic fields concerning real-world game production and teaching practices remain relatively unexplored. The current state indicates a need for further studies to inform educational strategies employed in game production education.

3 Methodology

Within the following sections the used methodology is described in more detail.

3.1 Material

3.1.1 BIP: Course Design. The purpose of the BIP was to improve students' comprehension of the processes involved in creating games and equip them with the necessary skills for collaborative and interdisciplinary digital game creation. It introduced established game creation techniques and technologies while promoting soft skills such as teamwork, creative thinking, problem-solving, communication, and providing and receiving peer feedback to achieve this. The BIP ran from the last week of February to the last week of April in 2023. The 8-week course employed a blended and project-based learning environment incorporating (indie) game industry methods and technological tools, thus simulating small-scale game creation. The learning environment, collaboratively designed by game scholars and industry professionals[1] , equipped the students with design and development fundamentals for VR games. It also acquainted them with tools like *Unity*, the *Oculus Quest* VR headset, its software development kit and the online communication platform *Discord*. Additionally, the program familiarizes students with various game industry creation procedures, such as working within the SCRUM framework, utilizing the collaborative goal-setting technique of **Objectives and Key Results (OKRs)** to monitor progress, foster alignment, and promote engagement around quantifiable objectives. It also covered the fundamentals of the 'remote-first' organizational strategy, equipping students with knowledge of contemporary approaches to teamwork and project management online (see Appendix B).

The BIP curriculum also highlighted the development and application of serious games, focusing on the transformative potential of games in education, sustainability, and healthcare. The learning environment was outlined to allow and enable the students to research, design, develop, test, evaluate and present their game prototype. The PBL environment posed three broad learning objectives, all regarded as assessment material contributing towards the overall course degree. Upon completing the BIP, students should have:

- Produced and presented a VR game prototype. The prototype should be regarded as a potential portfolio piece for future endeavors.
- Grasped the potential and limitations of VR as a game medium and apprehended the basics of game creation procedures and its connected skills.
- Gained insights into the importance of team building, collaboration, and communication in game creation, especially when working in a multicultural, interdisciplinary, hybrid context.

The BIP was organized as three interconnected course modules (Table 1).

3.1.2 BIP: Organizers and Students. The BIP students originated from various academic institutions. The majority of students came from Nord University (Norway), TU Wien (Austria), and IPCA (Portugal) - which were the organizing institutions. Moreover, academic institutions, including the University of Babeș-Bolyai (Romania), Vilnius Business College (Lithuania), and Hochschule Nordhausen (Germany), were represented (see Table 2).

The application criteria for BIP students were grounded on their academic performance, evidenced by their grades, as well as the submission of motivation letters by the applicants. These letters were required to express the applicants' interest in learning about game creation, ensuring that participants were not only academically capable but also genuinely interested in the specific

[1]See Appendix A.

Table 1. BIP Course Modules

Module 1: Online Lectures and Seminars (Weeks 1 and 2)	Module 2: Onsite Project-based Learning (Week 3)	Module 3: Online Project-based Learning (Weeks 4–8)
The BIP began with two weeks of daily online sessions from March 13 to March 24, approximately 27 hours of introduction activities (Appendix B). The sessions were crafted to engage students in dynamic activities, including team formation, creative brainstorming sessions, and online workshops with game practitioners and scholars. Module 1 was crafted to acquaint students with the implications of soft and hard skills in game creation. Emphasis was placed on the onboarding process, which facilitates team formation, fosters creative idea generation, and promotes a collaborative atmosphere.	An onsite module, which took place at IPCA in Portugal from March 26 to March 31 during a dedicated work-intensive week, offered a PBL environment to simulate real-world small-scale VR game creation. The onsite learning environment gave the student teams approximately 35 hours of game creation together with mentors from both academia and industry. Module 2 was designed to aid students in refining and iterating their game concepts, enabling them to apply their acquired knowledge to the project. The intention encourages transforming the student's theoretical knowledge into practical production skills. The module aimed to enhance team collaboration by simulating real-world independent game creation scenarios - while providing access to resources and mentors if needed.	The final segment ran from April 3 to April 28, involving 27 hours (9 hours per week) dedicated to developing and documenting the game project. Module 3 was designed to allow students to delve into the development process, focusing on both the execution of the game and the aspect of documentation. Teams collaborated to bring their game ideas to fruition, refining the design based on peer feedback and player testing. Simultaneously, participants were tasked with preparing documentation and a presentation that captured the development journey, design rationale, and learning outcomes. In Module 3, online mentoring sessions were offered to the teams.

Table 2. Organizing and Represented Institutions in the Project

Institution/Country	Project Role
Nord University (Norway)	Project Organizer
TU Wien (Austria)	Project Organizer
IPCA (Portugal)	Project Organizer
University Babeş-Bolyai (Romania)	Participating Organization
Vilnius Business College (Lithuania)	Participating Organization
Hochschule Nordhausen (Germany)	Participating Organization

Table 3. Student Demographics

Category	Information
Total Students	22
Students' Age Range	20–35 years
Most Populous Age Group	21–26 years
Students' Gender Distribution	Male: 16/Female: 6

Table 4. Students' Academic Background

Academic Background	Distribution
Computer Engineering	6
Games & Entertainment Technology	3
Applied Informatics	4
Data Science	3
Media & Communication Technology	4
Health Informatics	2

subject matter of the program. This dual criterion aimed to assemble a cohort of individuals who were both academically prepared and personally motivated to engage deeply with the content and objectives of the BIP. The BIP student cohort consisted of 22 international students from diverse academic backgrounds (Table 3 and 4).

3.2 Method

3.2.1 Focus Group Assembling and Data Collection Process. A qualitative focus group discussion strategy was chosen to accumulate the students' perceptions of learning about game creation in a PBL environment. The approach was considered appropriate for the study's exploratory nature as it facilitates the elicitation of rich and in-depth data, enabling nuanced comprehension [24]. Employing unstructured focus group discussion offered an opportunity to capture a broad spectrum of perspectives and insights from the students [24]. The authors predicted that such sessions would stimulate student interaction, enabling them to elaborate on one another's ideas, whether in agreement or disagreement, forming a dynamic discussion. The strategy aspired to encourage students to freely express matters and perspectives they might not reveal in individual face-to-face interviews.

In forming our focus groups, our procedure was guided by the aim of encompassing a wide range of student perspectives and perceptions concerning the BIP-provided learning experience and environment. The student segmentation in the groups was mainly based on their academic

Table 5. Student Profiles in the Study

Name in Study	Academic Background	IT Industry Experience	Focus Group
Student 1	Computer engineering	Yes	1
Student 2	Game & Entertainment Technology	No	1
Student 3	Media & Communication	No	1
Student 4	Applied Informatics	No	1
Student 5	Computer engineering	Yes	1
Student 6	Game & Entertainment Technology	No	2
Student 7	Health Informatics	Yes	2
Student 8	Data Science	No	2
Student 9	Media & Communication	No	2

background, degree, and previous practitioner experience in technology development. Following directives given by Morgan [31], Krueger and Casey [22], and Lazar et al. [24], we aimed to balance breadth, depth, relevance, and heterogeneity in the groups with hopes of yielding a representative discussion resulting in valuable insights and perspectives prolific for our investigation.

More specifically, we followed the recommendations of Morgan [31], who underscores the importance of depth and quality of data over quantity and thus advises that employing a small number of focus groups - usually two to three - in lengthy sessions is often more beneficial for eliciting rich insights, as opposed to organizing plenty yet short focus group discussions. A smaller number of groups has been argued to make the collected data manageable, facilitating familiarization and thoroughness in the analysis process, yielding more accurate and viable outcomes [24]. We also adhere to Krueger and Casey, who reason that groups with fewer participants - between four and six - accomplish more in-depth discussions while simultaneously furnishing each of them more space in the dialogue [22]. Therefore, two focus groups of six participants each were outlined from the five teams via a purposive sampling script. The script considered that each group comprised a representative balance regarding the academic disciplines and the varying levels of student academic/industry experience. The agreed-upon participants were contacted by email, and all but one accepted to participate, although there was an additional dropout (Table 5).

During the investigation, we adhered to Iphofen's principles to maintain a high research ethics level and achieve scientific integrity by employing ethnographic methods [18, 19]. Before conducting the focus group discussion, all participating students were informed about the study purpose. This included its aims, objectives, the collected data utilization, and storage time and location of the data. We also communicated to the students that their involvement in the study was entirely voluntary, and they could withdraw at any point. Students were informed that they would be anonymized in all forms of dissemination and that stringent measures would be taken to ensure their confidentiality. This information was initially provided in the invitation email and was reiterated and elaborated upon at the focus group sessions. Before recording the focus group discussions, students were asked to provide their consent, which all did.

The data collection phase began after the conclusion of the BIP in the spring of 2023. The two focus group sessions were held in May 2023, with a one-week interval between them, and were facilitated by Author 1 (as moderator) and Author 2 (as co-moderator). Each session, lasting approximately 80 minutes, was recorded and conducted online. The focus group sessions employed an unstructured, student-driven approach, where the moderator introduced broad topics and then adopted a passive role to encourage student-led discussions [24]. The moderators occasionally intervened to ensure each student could express themselves, prompting participants to share their thoughts and opinions on the topics discussed.

3.2.2 Data Analysis. Author 2 transcribed both focus group discussions verbatim in early June 2023, closely following the timing of their recording to achieve a faithful representation of the two sessions, aiming for high precision and accuracy in the transcripts. Moreover, transcribing the recording closely in time ensured that each session's unique context and discussions were preserved, facilitating differentiation between the two focus group sessions and mitigating the risk of interpretation bias that could arise if they were transcribed simultaneously. The analysis of the transcripts began in September and concluded in November 2023, employing a thematic analysis approach as outlined by Braun and Clarke [5]. Thematic analysis was deemed suitable for the study's exploratory design, which involved searching for participants' experiences, views, and opinions to identify patterns or themes within our collected data [41]. The thematic analysis consisted of three major phases: 1) initial coding, 2) theme generation, and 3) theme reviewing and iteration. Upon completing the third phase, the themes were ultimately defined and named.

In the first phase, the initial coding was independently performed by Author 1, employing an inductive-deductive approach [41]. The approach thoroughly examined the transcripts, identifying specific words, phrases, or incidents pertinent to the study's focus. The coding was conducted granularly, adhering closely to the literal content of the focus group data, allowing for the organic emergence of initial codes and avoiding the imposition of pre-existing categories or theoretical frameworks. The approach during the first phase enabled Author 1 to become highly familiar with the collected data, which later facilitated the identification of emerging patterns (second phase) and delineation the themes and sub-themes (third phase). Before commencing the second phase, Authors 1 and 5 engaged in thorough discussions regarding the codebook's interpretative agenda, textual meanings, and areas of uncertainty to ensure the schematic's dependability. The codebook was subsequently revised to enhance accuracy and consistency for the forthcoming analysis in phases 2 and 3, providing the trustworthiness and credibility of our findings and conclusions derived from the thematic analysis [2, 42]. Moreover, as the thematic analysis progressed into phases 2 and 3, it was decided to employ the data analysis software MAXQDA to enhance further the organization, traceability, efficiency and accuracy of the remaining thematic analysis process.

In the second phase, Authors 1 and 5 separately engaged in focused coding, identification of emerging patterns, interpretive analysis and initial theme generation based on the agreed-upon codebook. In the third phase, the authors reviewed, discussed, and revised the themes. It involved integrating and synthesizing the critical data segments into coherent themes and sub-themes. Table 6 provides a sample of the thematic analysis process.

4 Results

The thematic analysis of the focus group discussion transcripts yielded three comprehensive main themes – each consisting of two sub-themes – regarding the students' perceptions of the BIP: 1) *Preconditions and Prior Experience Influence Attitudes Towards the Educational Approach*, 2) *Technologies, Interactions, and Procedures within the Educational Context*, and 3) *Educational Factors that Influence Project Accomplishment and Student Collaboration.*

The excerpts from the student focus group discussions, presented within the thematic sections of the results, are intended to provide 'thick descriptions' of the inquiry under scrutiny [5]. The procedure is adopted to achieve transparency and enhance the study's trustworthiness [42].

Furthermore, by offering transparency in the focus group participants' statements about their experiences and perspectives of the BIP, we also seek to enable readers to formulate their conclusions based on the student's statements provided in the text. For the sake of transparency, it should be noted that due to the students' diverse linguistic backgrounds, there were grammatical inconsistencies in the discussions. Consequently, specific excerpts have undergone minor grammatical

Table 6. Sample of the Construction of the Format, Content and Prerequisites Theme

Student Excerpt	Initial Coding	Focused Coding	Sub-Theme
'Working with people with limited Unity experiences was pretty troublesome since I was the only one that could help my teammates. Helping them took all my time [...] this was not the case in all teams'	Student uneven skill distribution, Time constraints to learn, Project result depending on tool familiarity, Need for adjustment	Imbalanced familiarity / proficiency affects peers, Team composition, Support for students with prior experience, Seniority does not equal game tool proficiency	Tool proficiency and its impact on team dynamics
'These kinds of tools, Teams, Discord, Slack, they are effective, sure. But when it gets too big it gets too big and you cannot manage it anymore'	Student Challenges, Tool Utility, Tool Familiarity, Project Scale Impacts BIP?	Context-Specific Tool Limitations, Effectiveness of Tools, Issues emerges with project progression	
'I felt a little bit overwhelmed with Unity in itself [...] But other than that I think my skillset from before (other courses) was sufficient'	Overwhelmed by Unity, Need for better guidance, Sufficient prior skills?	Challenges in skill application, Self-guided learning, Balancing guidance and independence	
'the theoretical courses were not that new to me. But still, the practical week was in my opinion extremely beneficial to me in terms of team coordination and developing in a team together.'	Benefits of previous experience, Practical week, Team coordination, Developing in a team,	Teams sociocultural learning, Practical application of skills,	Prior practice shapes attitudes towards VR game creation
'Having the first weeks online where we actually prepared the game project [...] and then having one intense week in Portugal where we are already working as a team. It was a bit challenging [...] mostly because it was new to me'	Need for follow-up sessions Requires BIP onboarding, Importance of preparedness,	Time Management, Educational background, Differing academic traditions	

corrections, such as adjustments for dangling modifiers and instances of parapraxis. These modifications prevented misunderstandings and improved the given statements' logic and readability.

4.1 Students' Preconditions and Prior Experience Influenced Attitudes towards the Educational Approach

The students' perceptions of the instructional format, learning content, and implicit prerequisite skills associated with the VR game creation BIP are encompassed in the first theme.

4.1.1 Varied Prerequisites and Adherence to the BIPs Learning Approaches. The data analysis from the focus group discussion indicated that the students with prior experience in game development and its technology might require other skills, such as operating in blended learning environments. Student 2, who had an academic background in game development, highlighted the contrast between theoretical knowledge and practical experiences during the BIP: *'The theoretical*

courses were not that new to me. But still, the practical week was in my opinion extremely beneficial to me in terms of team coordination and developing in a team together'.

Similarly, Student 4 denoted, 'Having the first weeks online where we actually prepared the game project [...] and then having one intense week in Portugal where we are already working as a team. It was a bit challenging [...] mostly because it was new to me' (Student 4).

Students 2 and 4, with limited experience in blended- and project-based learning environments, preferred guidance on assembling and operating a VR game project, preferably through added onsite instruction. They suggested that the BIP would benefit from informing the students of how such learning processes function before the course commenced. This would have better equipped them for the practical self-directed work it involved.

The learning content and scheduling was another aspect discussed in the groups conveying wishes for improving the balance between theoretical and practical sessions: *'So one problem was that there were a lot of theoretical lectures held. These might have also just been recorded lectures that we could have watched whenever before the week in Portugal [...] again, we had, I think we had at least 2 or 3, lectures and those weren't really directly related to VR development*' (Student 3).

Student 3's statement indicates a preference for a more personalized, flexible, and relevant curriculum, emphasizing a more direct practical application of the teaching content. The sub-theme implies that engaging in blended learning environments might not naturally align with the inherent aptitudes of higher education students. Skills such as teamwork, problem-solving, and the capability to navigate and adjust to online learning environments might not be instinctual for all students or just not fit their daily schedules.

4.1.2 Prior Practice Shapes Attitudes towards VR Game Creation. The analyzed data suggested that BIP students' previous experiences in software development/engineering or computer science influenced their perceptions of the blended learning environment. Increased student experience correlated with heightened perplexity within the BIP context, which extended to the students' perceptions regarding the applicability of their skills to video games and VR creation. A notable example was a student who had experience in programming and industry software development but was new to game and VR development: *'the first time I actually got to learn about this [game creation] and this was the first time I was working on anything related to the gaming industry which was rather different from what I had done before'* (Student 5).

Another student stated: *'I was curious about how these games came to life and all that. With this, I got to know about that. And the factor that I liked the most was the hands-on approach of this'* (Student 1).

Student 1, who also had a background in software development, expressed mixed feelings of uncertainty and excitement about applying previously acquired skills to VR game projects, noting the differences from previous participation in software projects. Students 1 and 5 assert that game development differs from software projects in other domains. The sub-theme suggests that students with practitioner experience might be unable to apply to VR game creation. However, these expectations may not always align with real-world scenarios, leading to ambiguous sentiments.

4.2 Technologies, Interactions, and Procedures within the Educational Setting

The second theme captures the students' perspectives on the different technologies, peer-to-peer exchanges, and methods of understanding game creation in the BIP education setting.

4.2.1 Tool Proficiency and Its Impact on Team Dynamics. The focus group discussion provided insights into how the game project composition impacted students' perceptions of the BIP. A highlighted challenge pertains to the teams' diverse skill sets, particularly their familiarity and

proficiency with the game-creation tools provided in the course. Student 1 pointed out the difficulty in organizing the work and attributed this to the team members' limited acquaintance with the Unity tool: *'Working with people with limited Unity experiences was pretty troublesome since I was the only one that could help my teammates. Helping them took all my time [...] this was not the case in all teams'*.

Student 1 pointed out that the team capacities appeared unevenly distributed, and adjustments should have been made so that he could satisfactorily complete the course. Students also reflected on the challenges of quickly becoming familiar with Unity. One student expressed being *overwhelmed* by the game engine *Unity* but also recognized that his/her experience was a foundation for overcoming these challenges: *'I felt a little bit overwhelmed with Unity in itself [...] But other than that I think my skillset from before (other courses) was sufficient'* (Student 3). Another student expressed, *"We had one session for the Unity which was really great. But I feel there should have been a follow-up for that.'* (Student 8).

Excerpts from Students 3 and 8 indicate that a background in **information technology (IT)** can have a dual effect on students' aptitude to learn game creation due to the specific tools used. The discussion implies a similar discussion concerning the use of digital communication tools. All participating students employed the platform Discord for coordination and collaboration purposes. However, it was noted that that tool became problematic as the projects advanced: *'These kinds of tools, Teams, Discord, Slack, they are effective, sure. But when it gets too big it gets too big and you cannot manage it anymore'* (Student 2).

The observation underscores the utility of such communication platforms within the BIP context and the difficulties in maintaining effective communication through these tools as the project scale increases. The sub-theme depicts that working with tools commonly used in the game industry caused complications for some of the students' VR game projects. Due to the students' varying skill levels in using these tools, such as the Unity engine and the communication platform Discord, these technology devices were not necessarily within the students' proficiency, so they seemed to have caused concerns as the game projects proceeded.

4.2.2 Peer-to-Peer Learning and Project Conflicts. The focus group discussions specified various factors that either facilitate or impede the progression of their game projects. One topic discussed the value of the team's interdisciplinary skills in the learning environment: *'I learned some new things and explained some things that I've already knew. Working in teams with new people was also pretty nice since I haven't done that as much before, at my university.'* (Student 5).

Correspondingly, Student 3 noted: *'I liked learning a lot of stuff that I didn't know before, and I also liked that I learned a lot from the classmates, who helped us out, and from the tutors who mentored us as well'*.

The reflections indicate that students prefer an informal peer-to-peer approach in the learning environment for game creation. They discern the value of working with people from varied academic backgrounds and cultures, augmenting their learning experience. Moreover, the focus group discussions shed light on conflicts within their teams that arose during collaborative projects. A topic that seemed to cause team conflicts was the lack of student self-coordination and varied commitment in the online environments during the BIPs' third module. Student 9 described difficulty managing group meetings: *'One of the group members didn't really check the messages. And whenever we set up meetings, some of the group members always cancelled, like, at the last minute, making it hard to complete the project'*. Similarly, Students 7 and 8 stated:

Let's just say that maybe the communication could have been done better' (Student 7).

'So maybe, as Students 7 and 9 said, perhaps not everyone felt obligated to meet up and deliver something until a certain point' (Student 8).

The discussion underscores a source of conflict deriving from varying levels of commitment and availability among team members, which seems to affect the students' perception of the learning experience. Similarly, Student 2 reported challenges in project communication within their team, stating: *'Our group needed to make group-chats on other platforms as well [...] also the communication was pretty bad from certain group members.'*

This comment implies that communication difficulties were present, attributable partly to technological factors and partly to team dynamics.

Students 7, 8, and 9 noted that communication challenges frequently resulted in misunderstandings or delays in project progression, highlighting the necessity for more structured and transparent communication channels within teams. Student 2's excerpt precepts a similar notion; however, it also enfolds that technological issues may contribute to the difficulty of maintaining functioning communication in the project. The sub-theme displays the interdisciplinary learning opportunities for the students and the complexities of collaboration, communication, and project processes among interdisciplinary teams in BPL settings.

4.3 Educational Factors that affected Project Accomplishment and Student Collaboration

The third theme identifies certain aspects and circumstances in the physical and/or virtual educational spaces that the students alleged had an influence on their VR game project accomplishment, team collaboration, and personal growth.

4.3.1 Diverse Perspectives on Onsite and Online Learning Environments. The focus group discussions provided insights into students' experiences with the onsite/online composition of the BIP. Commencing online module complications arose. Student 9 described difficulties in team coordination and communication when not physically present*: 'I don't think there was anything that the professors could have done to help out in that sense. But yeah. I think the Portugal week was the easiest to do everything because we were all together'*. Student 2 uttered a similar notion: *'[A]s as soon as we came back, everything was supposed to be online, and we were supposed to organize stuff on our own. It was very hard to do'*.

The excerpts illustrate the complications considered in reproducing the onsite collaborative environment online. Not all students had issues with the onsite/online aspects; Student 6 expressed appreciation for the blended learning model, highlighting its flexibility and scope: *'There is not any other practical way of doing it. The whole setup week, one week physical and the rest of the weeks online. I guess that that's a really good mix'* (Student 6).

The statement suggests that the existing opinions of the onsite and online composition were sufficiently balanced. The sub-theme concerns the perceived balance of the onsite and online elements in the BIP learning environment. The students perceived the online/onsite composition as dissimilar. Students 2 and 9 regarded the online part, following the onsite week, as challenging to self-organize. Student 6, however, perceived the online/onsite composition as well integrated and regarded it as favorable learning about game creation.

4.4 The Importance of Networking Opportunities and Relationship Building

The focus group discussions elucidated that the students contributed importance of networking and relationship-building opportunities provided by the BIP learning environment. The networking facet was valued, contributing to the student's personal growth and professional development. For instance, Student 5 reflected on the multifaceted nature of their experience, noting: *'It was a great experience in various ways like not just academically, but in every possible way [...] I would like to point out the networking as the most important part, for me at least'*.

Furthermore, Student 6 stated: *'Even if she's a master student, she still needs to learn from me being a bachelor student for examples [...] Likewise, a lot of the bachelor student learned from the master students.*

Students 5 and 6 state the importance of the BIP function as a platform for connecting with peers and possibly future professionals acting in the same industry sphere. Also, the diversity and multidisciplinary nature of the BIP, which allowed student knowledge-sharing, seems to have contributed to a positive perspective on the learning environment.

Discussing the aspects of networking and relationship building, Student 7 reflected on the organized and instructor-led onboarding activities, emphasizing their significance in establishing a foundation and fostering understanding among the students: *'One of the best things, in my opinion, was like the first, I think it was the first one at least, it was the icebreaker challenges as we did as the very first thing in our assignment groups. I think that was very fun and important to do for us when we started up the whole thing [the BIP]'.*

The excerpt suggests that the students perceive the value of designing and organizing onboarding and team-building activities for students participating in BIPs. Furthermore, upon further discussing the networking capabilities incorporated into the BIP, it was noted that *'the week in Portugal was the best way to do it [networking] because we were all working together at the same hours in the day'* (Student 9).

The statement emphasizes the significance of having an onsite presence for developing functional group relationships, useful for the VR game project. Such initiatives seem to facilitate an open and inclusive learning environment, accommodate students, and facilitate relationship building. The sub-theme suggests that the students considered the BIP fruitful because it supplied networking possibilities and enabled interdisciplinary knowledge and skill-sharing.

4.5 Summary of Results

The results from the two focus group discussions on the students' experience learning VR game development in a blended environment are presented. The three themes underscore the complex dynamics of integrating prior experiences with new learning contexts, the challenges and opportunities of team-based projects, and the critical role of the learning environment in supporting personal and professional growth. A carefully balanced and responsive curriculum attentive to students' diverse needs and backgrounds can enhance the effectiveness of blended learning programs in specialized fields like (serious) game and VR development.

5 Discussion

Although numerous arguments suggest that PBL serves as a near-universal solution for linking lecture hall knowledge with work-life practice and applicable game-creation skills [3, 43, 46, 53], this study has unearthed some established issues with PBL, previously identified in research regarding engineering education [1, 11, 45]. It also highlights potential pathways for refining PBL within a blended learning environment in higher education, specifically focusing on game creation. Thus, the discussion provides ten considerations useful for practitioners and scholars seeking guidance in their curriculum design or inspiration for future research endeavors.

By juxtaposing our empirical findings with existing literature and the analytical lens of active learning techniques, we distilled insights into how such an approach affects higher education students' perceptions when acquiring and retaining game-creation skills. To some extent, our results mirror those of [20, 30, 43, 46], which argue that PBL techniques efficiently transform theoretical knowledge into applicable skills and foster transversal competencies – critical thinking, collaboration, and communication – in game projects. These competencies are essential in digital game creation, which involves collaboration among artists, programmers, designers, sound engineers,

and authors who bring diverse perspectives and expectations to any game project – however, our investigation also nuances and to some extent problematize previous findings.

Theme 1 illustrates that students with work-life experience encounter challenges adapting to the methodologies employed in (small-scale) game creation. The observation aligns with research on game development 'in the wild', suggesting that digital game creation is markedly different from other digital industries [21, 37]. Our investigation reveals a potential mismatch between theoretical knowledge and practical skills in game development and other IT fields. Students with experience in other IT fields may appear to possess the necessary skills for game development - e.g., programming and computer graphics - on paper, but in reality, they might not. Our study indicates this through student confusion about the game creation process. The finding suggests the necessity of providing a comprehensive explanation of the game creation process in game education, particularly for students with IT experience.

Furthermore, this finding proposes a usefulness of careful preparation and execution of game education *learning activities* to align with the students' *learning phases* [see 38]. These aspects of the finding align to some extent with previous scholars who have emphasized the importance of developing game curricula based on established frameworks [28, 30]. The result is also relevant for talent acquisition from other software domains. It may pose challenges in attracting and relocating a diverse array of senior technological professionals, including **user experience/interface (UX/UI)** designers, back-end developers, software engineers, data scientists, and experienced tech leads. Although proficient in their respective crafts, these roles might necessitate various reskilling endeavors to understand the work processes specific to game creation. Consider this is vital for educational providers offering courses aimed at reskilling tech-professionals into game creation, ensuring an adequate transfer of the specific competencies demanded by the game industry. Accentuating the distinctive aspects of game creation to participants with ample IT experience could, arguably, better prepare them and facilitate their participation in game projects.

Theme 1 also displayed diverse perception of higher education students regarding theoretical knowledge and practical experience. Game students with prior PBL experience found the practical BIP parts reasonable and appreciated working in a collaborative, student-driven setting. However, transitioning to a PBL environment seemed challenging for students unfamiliar with this educational approach, emphasizing the need for more detailed directions for navigating PBL environments. The adaptation challenges highlighted by some students suggest that not all higher education learners are naturally inclined towards PBL, suggesting anything but a straightforward acceptance of the educational approach. Engineering research has long stated that PBL is a complex process, and shifting towards it can put strain various educational stakeholders [45]. Students more accustomed to traditional learning environments suddenly need to apply new skills and step into roles they might not have required or done before, thus causing uncertainty and discomfort with their responsibilities [45]. The findings suggest that game education PBL might benefit from contemplating the following considerations:

- Students with experience in IT might have difficulties acclimating to game creation procedures, indicating that better support may be necessary to facilitate their transition from IT into game development.
- Reskilling from other technological fields to game development might be challenging for various stakeholders, indicating the necessity for well-thought-out strategies to incorporate previous skillsets effectively into game creation.
- The PBL approach may not be intuitive or straightforward for everyone; therefore, implementing a phased introduction could help students transition more smoothly into such educational environments.

Theme 2 reveals issues stemming from the technologies, interactions, and procedures within the PBL approach. BIP's reliance industry technologies Unity and, to some extent, Discord in the PBL environment created diverse hardships for some students due to varying proficiency levels. Students, although maintaining ample IT experience, reported difficulties familiarizing themselves with the Unity game engine. The finding indicates that game creation technologies, defining characteristic within the game industry [10, 34, 48, 50] may not be familiar to students within IT. Students skilled in specific areas, like programming, but unskilled with Unity saw themselves as unapt and unable to adequately perform assignments and responsibilities in their projects. On the other hand, students proficient in the Unity engine found themselves in the dual role of course participants and ad hoc instructors. This situation not only complicated the execution of their project tasks but also negatively affected team dynamics and project development, creating a cycle of tension and frustration. The initial disparity in tool familiarity or specific skill among students can evolve into a dependency relation, where less proficient students rely heavily on their more skilled peers to conduct their project work. The dependence can potentially stifle the students' learning focus, diverting their efforts toward learning the tool rather than the game creation process. Such dependency can be frustrating and demoralizing, particularly when students cannot contribute effectively to the project due to their different understanding and proficiency in the provided game-creation technologies.

Such 'technology lock-in' - for lack of a better word - might cause over-reliance on a single technology, which limits students' ability to fully engage in their learning because they must first understand the engines and platforms used in the educational environment. Inducing students to learn a tool (the form) instead of letting them learn and master a skill (the content) probably restricts their growth in digital game creation. To avoid technology lock-in, proactive strategies should be implemented that ensure that students have opportunities to succeed with their game project in the PBL environment with the least possible dependence on which tools are used. Providing support and access to several different resources and tools can possibly make it easier for all students to reach their set goals and complete their game projects. The finding that industrial technology can cause technology lock-in and hinder student skill development, especially in a PBL environment, contrasts with previous literature, where many advocate extensive use of game industry technologies in educational settings to better prepare students for the work-life [3, 30, 53].

Furthermore, Theme 2 depicts challenges in student communication and team member commitment, especially within the online phase of the BIP. Student communication emerged as a factor that, allegedly, influenced the game project accomplishment. The BIP provided the digital platform Discord facilitating initial coordination, but it was reported becoming less effective as project complexity increased. The irregularity in student commitment and the concern of online team coordination seems to have been something of catalyst the potential for conflict and miscommunication, which could influence the students' overall learning experience regarding the BIP.

The issues of varying commitment levels and the struggle to maintain effective synchronous communication has been highlighted in previous work on BIPs [36] and could be a potential area for intervention, possibly through proactive measures and better preparation for students' intuitive collaborations to employ solutions that can bridge communication gaps and foster a more collaborative learning experience. This finding implies a necessity for action aiming for a more consistent student engagement throughout the BIP, especially in PBL environments. Concluding Theme 2 it exhibits that while PBL offer hands-on learning opportunities, it also requires careful consideration of team dynamics, communication practices, and the combination of correct skillsets for wide-ranging realization. For future educational implementations with similar approaches, the following considerations could be useful:

- Students with low proficiency levels in the provided game creation technology faced additional learning challenges, potentially hindering their growth and contribution to the game project, suggesting that substantial training sessions are essential to bring all students to a similar proficiency level.
- Less proficient students might depend on more proficient peers to assist them, causing frustration and impacting team dynamics, suggesting implementing structured peer mentoring to balance support and independence.
- Over-reliance on a specific game-creation technology might limit student engagement and growth, suggesting the importance of incorporating a broader range of game-creation opportunities in the learning environment.
- Different levels of commitment and engagement affected team productivity and the game project outcome, underscoring the importance of facilitating interaction among team members and accommodating their educational circumstances.

Theme 3 depicts the dynamics of onsite/online learning environments, revealing diverse student experiences and each modality's inherent challenges and advantages. Some students reported difficulties maintaining the level of coordination and communication achieved during the onsite phase when transitioning to working online. However, not all students perceived the online phase as detrimental; some students had a positive stance towards the online environment, appreciating its flexibility. The different perceptions regarding the onsite/online environment are difficult to specify, and they might depend on students' prior educational experiences, such as blended- or project-based learning. The extent to which students have engaged with similar pedagogical approaches in the past could impact their responsiveness to the online/onsite environment. It is important to note that this is speculative, with no immediate solid evidence. Previous research on BIP indicates that the transition from onsite to online is a frequently discussed topic among educational stakeholders consisting of a lot of attitudes towards the online part [36]. Studies on blended learning show that some students do not consider the differences between the onsite and online learning environments overly significant [49]. The mixed perception among students regarding the BIP's onsite/online composition, even though we cannot determine its basis, underscore the necessity for game educators to consider designing and implementing blended learning carefully into their teaching of game creation. One recommendation is that the majority of activities in a virtual environment should be student-centered from the start [35, 36] which would align well with an active learning approach [29].

Theme 3 furthermore emphasized networking opportunities as positive aspects of the student's learning experience, emphasizing their role in enhancing PBL by laying the groundwork for professional growth and development. These networking opportunities were perceived as elements that fostered a comprehensive experience extending beyond academic achievements, serving as a foundation for developing transversal competencies – soft skills. The students' statements highlighted two key aspects facilitating team-building and prospective student networking. First, the onboarding activities were pinpointed as beneficial as they fostered a collaborative group dynamic within the game creation project. Second, the physical week, which included various team-based and game-related leisure activities, bolstered students' cooperation and networking. These observations indicate the critical nature of instructor-led onboarding and an onsite team meetup or 'kick-off' in the multicultural and multidisciplinary context typical of game creation projects. These findings echo prior research [23, 35, 36] by emphasizing the necessity for game educators to move beyond merely prescribing tasks or suggesting student objectives. Instead, there is a highlighted need to balance the onsite and online elements in collaborative projects tailored for game

students, as previously proposed [13, 39]. Striking this balance is vital for enabling students to develop their transversal competencies. While online environments and digital platforms offer geographical flexibility, onsite interactions – capable of swiftly cultivating strong and functional group relationships – seem necessary for the student, although to a varied extent. For future educational implementations with similar approaches, the following considerations could prove valuable:

- Some students perceived difficulties in maintaining project coordination during the transition from onsite to online phases, suggesting that implementing structured communication protocols and/or regular check-ins can facilitate smooth transitions and maintain prolific team collaboration.
- Students' experiences indicate that structured onboarding activities, team-building exercises, and initial onsite meetups are essential for fostering a collaborative group dynamic and supporting team cohesion from the outset.
- Networking was perceived as an opportunity for professional growth and development, suggesting that facilitating structured networking events and activities, such as initial onsite meetups, that extend beyond academic achievements fosters a collaborative group dynamic and supports team cohesion throughout the game-creation project and afterwards.

5.1 Conclusion

This study contributes to understanding teaching game creation in a BIP that practices a PBL approach. By investigating students' perceptions our study offers an exploration of PBL within the context of game creation education, emphasizing both the potencies and challenges of this pedagogical approach. While PBL has been heralded for its ability to convert theoretical knowledge into applicable skills – especially in fostering transversal competencies that are in high demand not only in the game industry but in the workplace in general – our findings suggest that PBL's usefulness in game creation teaching is contingent upon several factors.

The investigation revealed that students with prior work-life experience in IT encountered challenges adapting to PBL methodologies in game creation. This finding underscores the distinctiveness of game development as a field and highlights the necessity for educational strategies that explicitly address game creation's distinctive aspects, including using industry-specific tools like Unity. Moreover, the study identifies a barrier in the form of technology lock-in, which can hinder the learning process and limit students' ability to engage thoroughly with the material.

The analysis further points to the importance of structured support and preparation in facilitating a smooth transition to PBL environments, especially for students unfamiliar with such learning approaches. This support includes the need for a phased approach to learning that balances the acquisition of soft skills, such as teamwork and communication, with hard skills, such as graphics, design, and programming. Additionally, our findings highlight the critical role of communication and team dynamics in the success of PBL projects, suggesting that more robust support structures and explicit expectations are necessary to enhance collaborative learning experiences.

The diverse student experiences with the blended learning environment, comprising both onsite and online phases, reveal the complexities of maintaining engagement and productivity across different learning modalities. While some students appreciated the flexibility offered by online learning, others struggled with the transition, pointing to the need for course designs that better accommodate diverse learning preferences and backgrounds. The examination emphasizes the value of networking opportunities and structured onboarding activities in enhancing the PBL experience, underscoring the importance of fostering a supportive and collaborative learning environment. These findings suggest that game educators must carefully consider the balance between onsite

and online elements in their teaching approaches, ensuring that students are equipped with the necessary skills and support to navigate the challenges of game creation education effectively.

5.2 Limitations and Future Research Directions

The findings of this study, with its focus on a BIP for VR game creation, are inherently contextually specific. The distinctive game-creation process [12], learning objectives, tools, content, and the particular structure of a BIP directed towards game creation suggest that the conclusions may not be universally applicable to all disciplines, including other game education contexts, thus limiting the generalizability of the outcomes. While the study provides insights into students' perceptions, it is essential to note that not all participants are game students, which might influence their stated perceptions. The study does not disclose how well these perceptions convert into educational strategies that measurably impact learning outcomes. Additionally, the investigation does not measure the efficacy of PBL and blended learning strategies for learning game creation regarding hard and soft skills.

It is important to recognize that this study's findings are based on a specific educational context and a relatively small sample size, limiting the findings' generalizability. Additionally, biases may be present in the focus group method, attributable to the dual roles of the authors/interviewers as educators. Moreover, when the focus groups were conducted, the participants had not yet received their grades. The thematic analysis approach allows for explorative semantic-level coding to ensure that the students' focus group discussions are primus motor in the investigation. However, the researchers' pre-existing assumptions influence the construction of themes, and data interpretation should be considered when viewing our findings - see further [5].

Practitioners should consider these limitations when applying the study findings in their course design for BIP implementations or other educational contexts. By addressing the identified challenges and leveraging PBL's strengths, educators can enhance the learning experience and better prepare students for the complexities of game development in the professional world.

In light of the study findings, future research and practice should aim to refine PBL methodologies and blended learning strategies in game education, considering students' specific needs and experiences. Given that the study included participants who are not all game students, future research could investigate how solely game students perceive a BIP on game creation. Likewise, exploring how learning objectives and tools within the BIP framework impact the effectiveness of VR game creation education is crucial. This inquiry could include more complex game creation lectures, and the types of tools used. Additionally, assessing the influence of these variables on student engagement, creativity, and learning outcomes is essential.

Future research could also expand on this work by exploring similar educational interventions in diverse cultural and institutional contexts and conducting longitudinal studies to track the career trajectories of game-creation students. Experimental studies implementing various strategies and assessing their impact on student performance, motivation, and satisfaction can provide evidence-based recommendations for educators. Longitudinal studies could address the conversion of student perceptions into measurable learning outcomes. These studies should track the impact on students' skills, knowledge retention, and career readiness over time. Tracking BIP students' post-program performance could provide more in-depth insights into the intervention's long-term efficacy in fostering the transversal skills sought by the game industry [16].

Researchers should use comprehensive evaluation methods, including pre- and post-intervention assessments and mixed methods combining qualitative insights with quantitative data, to assess the research contribution's efficacy and assess how well these approaches impact students' learning outcomes. Additionally, purposive sampling that considers academic levels (e.g., undergraduate, graduate) and expanded sample size could lead to more assertive, actionable

conclusions and recommendations, thereby improving the generalizability and applicability of the findings.

Appendices

In this portion of the manuscript, we offer insight into the experience of the designers and executors of the BIP presented in the paper (Appendix A) and the lectures given in Module 1 (Appendix B).

Appendix A

The featured table summarizes the scholars' and practitioners' game-creation experience.

Table 7. Educators in the BIP

Gender	Age	Nationality	Academic Level	Degree	Previous Professional Game Experiences
Male	38	italy	Associate Professor	PhD in Informatics	10 years of practical experience in serious game production, complemented by 9 years of teaching and conducting research in higher education on topics related to game design, development, and implementation.
Male	39	Sweden	Associate Professor	PhD in Applied Information Technology	14 years of real-world game creation experience / 6 years of higher education teaching and research experience on game- design, development, implementation and related topics.
Female	48	Portugal	Associate Professor	PhD in Human–computer interaction	15 years of game design and game development within academic setting /20 years of higher education teaching and research experience on game- design, development, implementation and related topics.
Male	53	Norway	Associate Professor	PhD in Informatics	14 years of experience in game design within an academic setting.
Male	42	Austria	Associate Professor	PhD in Informatics	13 years experience on serious game design within an academic context.
Male	44	Portugal	Associate Professor with Habilitation	PhD in Industrial Electronics	15 years of experience in serious games research and development of games development engineering programs.

Appendix B

Besides emphasizing serious games and VR, the BIP lectures were designed to equip students with the theoretical knowledge and practical skills necessary to develop their game prototype successfully during the 8-week period. This table provides a concise overview of each Module 1 lecture in the BIP.

Table 8. Module 1 Lectures

Category	Lecture Description
Game Design	Introduces foundational principles of game design, focusing on mechanics, dynamics, and aesthetics. Explores game genres, narrative, player agency, and the iterative design process. Emphasizes prototyping, playtesting, and refinement.
Teamwork	This session introduced students to the importance of teamwork in collaborative projects. It covers team dynamics, roles, conflict resolution, and communication skills. It also highlights the importance of diversity and inclusion and includes practical teamwork exercises.
Scrum in Game Development	Introduces Scrum within Agile methodologies for managing game development projects. Covers roles (Scrum Master, Product Owner, Development Team), artefacts (Product Backlog, Sprint Backlog), and practices (Sprint Planning, Daily Scrums, Sprint Reviews, Retrospectives). Emphasizes flexibility, collaboration, and continuous improvement.
Intro to Serious Games	This session provides an overview of serious games designed for education, training, health, and social change. It discusses the history, development, and impact of serious games and balances objectives with engaging gameplay.
Serious Games in Healthcare	This lecture examines the application of serious games in healthcare for treatment, rehabilitation, education, and health promotion. It explores games that improve physical and mental health, support behavioral change, and enhance patient education. The course addresses design challenges and ethical considerations.
Brainstorming & Idea Creation	The session focuses on creativity and ideation techniques in game development. Covers brainstorming methods, concept generation, and fostering a creative environment. Includes practical exercises for generating innovative game ideas.
Serious Games and Sensor Technologies	The session discusses how sensors might be incorporated in serious games and how this data can be further used. This session contains case studies and real examples.
Team Building	The session emphasizes building cohesive teams for game development. It covers team formation, development stages, and cultivating a positive culture. It also includes interactive activities on leadership, communication, and collaboration skills.
Unity Engine	The session was an introduction to the Unity engine, covering navigation, scripting in C#, and development tools. Includes foundational knowledge of game objects, components, physics, and animations for developing games in Unity.
VR Game Design	The session focuses on designing games for virtual reality, covering unique mechanics, narrative design, and user interaction specific to VR. It also explores immersive design principles for engaging and comfortable VR experiences.
VR Game Development	Delves into technical aspects of VR game development, including SDKs, performance optimization, motion tracking, and user input. Guides students through developing VR game designs into functioning games with case studies and best practices.
Playtesting and Data Analysis	The session explores playtesting's role in game development, focusing on gathering and analyzing player feedback. Covers quantitative and qualitative analysis techniques, usability testing, and iterating game designs based on feedback to improve gameplay.
OKRs for game creation	This lecture integrates the Objectives and Key Results (OKRs) concepts with Agile methodologies to enhance efficiency and effectiveness in game creation. It outlines setting ambitious objectives aligned with key results to measure success. The session explores integrating OKRs, facilitating better team alignment, focus, and accelerated progress towards game development goals.

Acknowledgement

Our appreciation extends to the participating students, whose engagement and feedback provided us with the data necessary for our investigation, and to the industry experts volunteering as guest lecturers and idea generators in the BIP.

References

[1] César Antonio, Rodríguez González, José Maria Fernández Batanero, and Fernández Batanero. 2016. A review of problem-based learning applied to engineering. *International Journal on Advances in Education Research* 3 (2016), 14–31.

[2] Michael Belotto. 2018. Managing the challenges of coding, interrater reliability, and thematic analysis. *The Qualitative Report Data Analysis Methods for Qualitative Research* 23, 11 (2018), 2622–2633.

[3] Rafael Bidarra, Jerke Boers, Jeroen Dobbe, and Remco Huijser. 2008. Bringing a pioneer games project to the next level. *Proceedings - 3rd International Conference on Game Development in Computer Science Education, GDCSE 2008* (2008), 11–15. https://doi.org/10.1145/1463673.1463676

[4] Curtis Bonk, Charles R. Graham, and Jay Cross. 2005. *The Handbook of Blended Learning: Global Perspectives, Local Designs* (1st ed.). Pfeiffer.

[5] Virginia Braun and Victoria Clarke. 2006. Using thematic analysis in psychology. *Qual. Res. Psychol.* 3, 2 (2006), 77–101.

[6] Heather Maxwell Chandler. 2020. *The Game Production Toolbox*. CRC Press. https://doi.org/10.1201/9780429440021/GAME-PRODUCTION-TOOLBOX-HEATHER-CHANDLER

[7] D. Cohen and S. Bustamante. 2009. Producing Games: From Business and Budgets to Creativity and Design (1st ed.). Routledge. https://doi.org/10.4324/9780080928043/PRODUCING-GAMES-COHEN-MICHAEL-MCSHAFFRY-SHERI-GRANER-RAY-SERGIO-BUSTAMANTE

[8] European Commission. 2022. *Blended Mobility Implementation Guide for Erasmus+ Higher Education Mobility KA131*. Publications Office of the European Union. Retrieved from https://data.europa.eu/doi/10.2766/467485

[9] European Commission. 2023. *The Erasmus+ Programme Guide 2024: The Essential Guide to Understanding Erasmus+ (Version 1)*. Publications Office of the European Union. Retrieved from https://erasmus-plus.ec.europa.eu/erasmus-programme-guide

[10] Mia Consalvo and Christopher A. Paul. 2018. "If you are feeling bold, ask for ∃3": Value crafting and indie game developers. *Transactions of the Digital Games Research Association* 4, 2 (2018), 51–75. https://doi.org/10.26503/todigra.v4i2.89

[11] Bettina Dahl. 2018. What is the problem in problem-based learning in higher education mathematics. *European Journal of Engineering Education* 43, 1 (2018), 112–125. https://doi.org/10.1080/03043797.2017.1320354

[12] Henrik Engström. 2020. *Game Development Research* (1st ed.). University of Skövde, Skövde.

[13] Tobias Ferreira Da Rocha Neto, Kleber Tavares Fernandes, Eduardo Aranha, Marcia Lucena, and Isabel Nunes. 2018. Educational digital game production: A survey on practice in the educational context. *Proceedings - 13th Latin American Conference on Learning Technologies, LACLO 2018* (2018), 470–475. https://doi.org/10.1109/LACLO.2018.00084

[14] Lindsay D. Grace. 2023. Global games education now. *Games: Research and Practice* 1, 4 (2023), 1–2. https://doi.org/10.1145/3632364

[15] Ulf Hagen. 2011. Designing for player experience: How professional game developers communicate design visions. *Journal of Gaming and Virtual Worlds* 3, 3 (2011), 259–275. https://doi.org/10.1386/JGVW.3.3.259_1

[16] K. Hiltunen, S. Latva, L. Sauri, and E. Tyynelä. 2024. *The State of the European Game Industry and How to Unleash Its Full Potential*. Retrieved October 20, 2024 from https://eit-culture-creativity.eu/wp-content/uploads/2024/03/The-state-of-the-Europen-game-industry-and-how-to-unleash-it%C2%B4s-full-potential.pdf

[17] M. B. Horn and H. Staker. 2014. *Blended: Using Disruptive Innovation to Improve Schools*.

[18] Ron Iphofen. 2020. *Handbook of Research Ethics and Scientific Integrity*. Springer International Publishing, Cham. https://doi.org/10.1007/978-3-030-16759-2

[19] Ron Iphofen. 2021. *Research Ethics in Ethnography/Anthropology*. Retrieved February 6, 2022 from https://ec.europa.eu/info/funding-tenders/opportunities/docs/2021-2027/horizon/guidance/research-ethics-in-ethnography-anthropology_he_en.pdf

[20] Tanat Jiravansirikul, Tuang Dheandhanoo, and Marissa Chantamas. 2017. University-industry collaboration for game curriculum: The open innovation model. In *2017 9th International Conference on Information Technology and Electrical Engineering (ICITEE)*, October 2017. IEEE, 1–4. https://doi.org/10.1109/ICITEED.2017.8250501

[21] Kristine Jørgensen. 2019. Newcomers in a global industry: Challenges of a Norwegian game company. *Games Cult.* 14, 6 (2019), 660–679. https://doi.org/10.1177/1555412017723265

[22] R. A. Krueger and M. A. Casey. 2015. *Focus Groups: A Practical Guide for Applied Research* (5th ed.). Sage Publication.
[23] Scott Kuhl, Robert Pastel, Ryan George, Chad Meyers, Matthew Freitag, Jacob Lund, and Michael Stefaniak. 2014. Teaching interdisciplinary teamwork through hands-on game development. In *2014 ASEE Annual Conference & Exposition Proceedings*, 2014. ASEE Conferences, 24.1165.1–24.1165.16. https://doi.org/10.18260/1-2–23098
[24] Jonathan Lazar, Jinjuan Heidi Feng, and Harry Hochheiser. 2017. *Research Methods in Human-Computer Interaction* (2nd ed.). Morgan Kaufmann Publishers. https://doi.org/10.1016/b978-0-12-805390-4.00014-5
[25] A. G. Madden, L. Margulieux, R. S. Kadel, and A. Goel. 2019. *Blended Learning: A Guide for Practitioners and Researchers*. MIT Press.
[26] B. Berg Marklund, H. Engström, M. Hellkvist, et al. 2019. What empirically based research tells us about game development. *Comput Game J* 8 (2019), 179–198. https://doi.org/10.1007/s40869-019-00085-1
[27] Paul Martin. 2018. The intellectual structure of game research. *International Journal of Computer Game Research* 18, 1 (2018). Retrieved October 20, 2024 from https://gamestudies.org/1801/articles/paul_martin
[28] Monica M. McGill. 2010. Collaborative design of cross-disciplinary game minors based on the IGDA curriculum framework. In *Proceedings of the Fifteenth Annual Conference on Innovation and Technology in Computer Science Education*, 2010. ACM, New York, NY, USA, 259–263. https://doi.org/10.1145/1822090.1822163
[29] Christian Mercat. 2022. Introduction to active learning techniques. *Open Education Studies* 4, 1 (2022), 161–172. https://doi.org/10.1515/EDU-2022-0010/HTML
[30] Koji Mikami, Taichi Watanabe, Katsunori Yamaji, Kenji Ozawa, Akinori Ito, Motonobu Kawashima, Ryota Takeuchi, Kunio Kondo, and Mitsuru Kaneko. 2009. Construction trial of a practical education curriculum for game development by industry/university collaboration. In *ACM SIGGRAPH ASIA 2009 Educators Program*, 2009. ACM, New York, NY, USA, 1–6. https://doi.org/10.1145/1666611.1666618
[31] David Morgan. 1997. *Focus Groups as Qualitative Research* (2nd ed.). Sage Publications.
[32] Emerson Murphy-Hill, Thomas Zimmermann, and Nachiappan Nagappan. 2014. Cowboys, ankle sprains, and keepers of quality: How is video game development different from software development? In *Proceedings of the 36th International Conference on Software Engineering*, 2014. ACM, New York, NY, USA, 1–11. https://doi.org/10.1145/2568225.2568226
[33] Johanna Nylander. 2023. *Making Games: Introduction to Skills and Jobs in the Games Industry*. Swedish Games Industry, Stockholm. Retrieved October 20, 2024 from https://static1.squarespace.com/static/5a61edb7a803bb7a65252b2d/t/63f215a836234123989fc126/1676809653101/Talent+Education+and+the+Art+of+Making+Games.pdf
[34] C. O'Donnell. 2014. *Developer's Dilemma: The Secret World of Videogame Creators*.
[35] Robert O'Dowd. 2022. *Internationalising Higher Education and the Role of Virtual Exchange*. Routledge, London. https://doi.org/10.4324/9781315393704
[36] Robert O'Dowd and Sina Werner. 2024. The first steps of blended mobility in European higher education: A survey of blended intensive programmes. *J. Stud. Int. Educ.* (2024). https://doi.org/10.1177/10283153241235704
[37] Adam Palmquist. 2019. A product to gamify other products; Implementing gamification in existing software. In *2019 11th International Conference on Virtual Worlds and Games for Serious Applications (VS-Games)*, September 2019. IEEE, 1–8. https://doi.org/10.1109/VS-Games.2019.8864535
[38] Margus Pedaste, Mario Mäeots, Leo A. Siiman, Ton de Jong, Siswa A. N. van Riesen, Ellen T. Kamp, Constantinos C. Manoli, Zacharias C. Zacharia, and Eleftheria Tsourlidaki. 2015. Phases of inquiry-based learning: Definitions and the inquiry cycle. *Educational Research Review* 14 (2015), 47–61. https://doi.org/10.1016/j.edurev.2015.02.003
[39] Chao Peng. 2015. Introductory game development course: A mix of programming and art. In *2015 International Conference on Computational Science and Computational Intelligence (CSCI)*, 2015. IEEE, 271–276. https://doi.org/10.1109/CSCI.2015.152
[40] Michael Prince. 2004. Does active learning work? A review of the research. *Journal of Engineering Education* 93, 3 (2004), 223–231. https://doi.org/10.1002/j.2168-9830.2004.tb00809.x
[41] Johnny Saldaña. 2013. *The Coding Manual for Qualitative Research* (2nd ed.). Sage Publication.
[42] Andrew K. Shenton. 2004. Strategies for ensuring trustworthiness in qualitative research projects. *Education for Information* 22, 2 (2004), 63–75. https://doi.org/10.3233/EFI-2004-22201
[43] Isabel Cristina Siqueira da Silva. 2022. The convergence between challenge-based learning and game design thinking methodologies: Exploring creativity and innovation in the game development process. *Research Anthology on Game Design, Development, Usage, and Social Impact* (2022), 1891–1907. https://doi.org/10.4018/978-1-6684-7589-8.CH092
[44] Alexander Styhre. 2020. *Indie Video Game Development Work: Innovation in the Creative Economy*. Palgrave Macmillan. https://doi.org/10.1007/978-3-030-45545-3/COVER
[45] Vilma Sukackė, Aida Olivia Pereira de Carvalho Guerra, Dorothea Ellinger, Vânia Carlos, Saulė Petronienė, Lina Gaižiūnienė, Silvia Blanch, Anna Marbà-Tallada, and Andrea Brose. 2022. Towards active evidence-based learning in engineering education: A systematic literature review of PBL, PjBL, and CBL. *Sustainability* 14, 21 (2022), 13955. https://doi.org/10.3390/su142113955

[46] Olga Timcenko, Lise Busk Kofoed, Henrik Schoenau-Fog, and Lars Reng. 2017. Purposive game production in educational setup: Investigating team collaboration in virtual reality. In *Communications in Computer and Information Science*. Springer Verlag, 184–191. https://doi.org/10.1007/978-3-319-58753-0_29

[47] Fridolin Sze Thou Ting, Wai Hung Lam, and Ronnie Homi Shroff. 2019. Active learning via problem-based collaborative games in a large mathematics university course in Hong Kong. *Educ. Sci. (Basel)* 9, 3 (2019), 172. https://doi.org/10.3390/educsci9030172

[48] Markus Toftedahl and Henrik Engström. 2019. A taxonomy of game engines and the tools that drive the industry. In *DiGRA Conference Proceedings 2019*, 2019. DiGRA.

[49] Keith J. Topping, Walter Douglas, Derek Robertson, and Nancy Ferguson. 2022. Effectiveness of online and blended learning from schools: A systematic review. *Review of Education* 10, 2 (2022). https://doi.org/10.1002/rev3.3353

[50] J. R. Whitson. 2018. Voodoo software and boundary objects in game development: How developers collaborate and conflict with game engines and art tools. *New Media & Society*, 20, 7 (2018), 2315–2332. https://doi.org/10.1177/1461444817715020

[51] Jennifer R. Whitson. 2020. What can we learn from studio studies ethnographies?: A "messy" account of game development materiality, learning, and expertise. *Games Cult.* 15, 3 (2020), 266–288. https://doi.org/10.1177/1555412018783320

[52] Peta Wyeth, Joshua Hall, Marcus Carter, April Tyack, and Roger Altizer. 2018. New research perspectives on game design and development education. In *Proceedings of the 2018 Annual Symposium on Computer-Human Interaction in Play Companion Extended Abstracts*, 2018. ACM, New York, NY, USA, 703–708. https://doi.org/10.1145/3270316.3271550

[53] Chang Yun, Hesam Panahi, and Zhigang Deng. 2016. A multidisciplinary, multifaceted approach to improve the computer science based game design education: Methodology and assessment. *SIGCSE 2016 - Proceedings of the 47th ACM Technical Symposium on Computing Science Education* (2016), 570–575. https://doi.org/10.1145/2839509.2844582

Received 29 April 2024; revised 5 July 2024; accepted 14 October 2024