

Towards Integrating Digital Preparedness into Higher Education

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Abstract: Integrating disaster preparedness education into higher education curricula faces persistent challenges in terms of engagement, relevance, and practical skill development. Recent advancements in digital tools offer promising opportunities to address these gaps through more interactive and experiential learning approaches, fostering disaster preparedness competencies among students, including enhanced risk awareness and improved emergency decision-making. However, embedding such tools into academic curricula requires careful alignment with pedagogical goals, institutional systems, and stakeholder expectations. This paper examines pathways for integrating modern digital preparedness tools into university education through a single case study. Data was collected based on semi-structured questionnaires from educators, students, and first responders at a Norwegian University. Experiences from an EU-funded project that developed an ecosystem (B-Prepared) for preparedness, including four digital products: virtual reality (VR-prepared), mobile technologies (IM-prepared), a learning management system (RU-prepared), and a knowledge management system (Disastropedia), were also considered. The results indicate positive attitudes toward embedding preparedness modules into existing courses. However, to be useful, the Learning Management System (LMS) should include a user flow on emergency preparedness and provide concrete examples on technology integration in a curriculum. The paper further discusses key challenges related to knowledge transfer, pedagogical alignment, and institutional infrastructure.

Keywords: Virtual reality, Emergency preparedness, Training, Education, Knowledge transfer

1. Introduction

Disasters and emergencies continue to pose significant risks to communities worldwide, making it increasingly important to foster disaster preparedness among all sectors of society, including university students (Paton, 2003, Ronan et al., 2015, Becker et al., 2012). Higher education institutions provide an ideal setting for promoting such preparedness, as students often become future community leaders and decision-makers. However, disaster education is not yet a standardized part of university curricula in many countries, and its integration faces both pedagogical and organizational challenges (Shiwaku and Fernandez, 2011, Shaw et al., 2004, Patel et al., 2023).

Traditional disaster education often relies on lecture-based instructions in a classroom situation, which may not sufficiently engage students or promote practical readiness skills (Johnson et al., 2014, Patel et al., 2023). The practical training is typically conducted through training evacuations following a fire alarm at the organization. While several new planning solutions are available, providing regular training at organizations remains challenging (Jalilov, 2025). This is especially true at universities, where there are many students and a variety of different groups. According to our present knowledge, there are no special courses available for evacuation training. There are no responsibilities or structures for this. For this, it would be necessary to align the disaster preparedness course or module with existing curriculum outcomes in the diverse academic disciplines. The motivation behind this paper is to investigate the opinions of the main stakeholders, namely teachers, students, and firefighters, on integrating a digital preparedness module into existing courses.

In general, educators often express uncertainty about how to integrate such new content effectively into an already running curriculum (Shaw et al., 2004, Shiwaku and Fernandez, 2011). For this, both educators and learners prefer a variety of digital tools (Frøland et al., 2020). Emerging technologies, such as Virtual Reality (VR), Augmented Reality (AR), gamification, and serious games, offer promising avenues to enhance engagement and experiential learning in this domain (Allcoat and von Mühlennen, 2018, Boyle et al., 2016, Heldal, 2016). Prior studies have demonstrated that immersive simulations can foster a more profound understanding of hazards and emergency procedures (Allcoat and von Mühlennen, 2018, Wijkmark et al., 2022, Hsu et al., 2013). Gamification techniques can also motivate learners to engage actively with preparedness content (González et al., 2018, Boyle et al., 2016). This paper examined how new technologies can enhance emergency preparedness. The reason for focusing on new technologies is to engage students in their use. An additional motivation is from the ongoing European B-Prepared project context (European_Commission, 2023), which explores civilians'

preparedness by using different technologies. This paper examines how new technologies used in an educational module can contribute to increased preparedness by exploring the possibilities for integrating such modules into higher education curricula at a Norwegian university.

The overall aim is to contribute to a better understanding of possibilities for embedding preparedness modules into existing university courses through investigating attitudes from the involved stakeholders, i.e., educators who need to integrate such modules in their courses, students who need to learn more about emergency preparedness, and firefighters who need to ensure that evacuation procedures and safety instructions are appropriate. The data used in this paper comes from semi-structured questionnaires conducted with key institutional stakeholders, including educators, students, and first responders, and also considering lessons from the B-prepared project (European Commission, 2023).

2. Technological Innovations for Disaster Preparedness Education

2.1 Implementing New Technologies for Disaster Preparedness

Disaster incidents are inherently complex and unpredictable, and traditional training methods for preparedness can be costly and difficult to scale. With the rapid advancement of consumer-grade virtual reality (VR) hardware and mobile technologies, immersive training solutions have become more affordable and accessible at universities (Radianti et al., 2020).



Figure 1: All the Products from B-prepared: a VR game, mobile technology (MT), a knowledge sharing plat-form 'Disastropedia', and a learning management system (LMS)

Leveraging these technologies to train university students on disaster and emergency preparedness can play a crucial role in mitigating future disaster risks (Zhang et al., 2023, Keya Tasnim et al., 2024). The ongoing European project B-Prepared (European Commission, 2023) is developing a suite of digital tools aimed at enhancing disaster preparedness education through innovative technologies (see Figure 1). The project's ecosystem consists of several complementary components:

- a mobile-based application, **IM-prepared**, offering geolocation-guided walks (GPS-based), presenting historical disaster scenarios and puzzle-based learning games. The application is being further extended by incorporating augmented reality (AR) games.
- **VR-prepared** is a VR-based serious game platform featuring two separate scenarios: wildfire preparedness and flood preparedness (King Tide). Both scenarios support multiplayer functionality, allowing multiple participants to interact simultaneously within the virtual environment and practice coordinated decision-making and evacuation.
- a dynamic knowledge-sharing platform, **Disastropedia** (Ekon, 2024), designed to allow users to contribute, access, and share information on disasters and preparedness strategies. All newly created content is reviewed and approved by a dedicated curation board to ensure accuracy and reliability.
- an integrated Learning Management System (LMS), **RU-Prepared**, based on Moodle, a widely used open-source LMS platform in higher education, that serves as the central integration point for all project components.

Within the B-Prepared ecosystem, Single Sign-On (SSO) functionality is being planned to implement, allowing students with an account in RU-prepared to access IM-prepared, VR-prepared, and Disastropedia. Progress tracking is also supported within RU-prepared. Full integration with university Learning Management System (LMS) platforms, such as Canvas, is under discussion.



Figure 2: Figure (a) shows a VR-prepared (King Tide) multiplayer flood preparedness scenario, and (b) shows an IM-prepared AR-based CPR training game

Two example games developed within the B-Prepared project are illustrated in Figure 2. Figure 2(a) shows a VR-prepared scenario that supports multiplayer functionality, allowing participants to collaboratively practice wildfire and flood preparedness in immersive virtual environments. Figure 2(b) presents an AR-based game in which users must correctly identify and position their hands to perform CPR compressions on an unconscious person. The activity is time-constrained, and users must complete the task accurately to succeed in the game.

By combining immersive technologies with gamification strategies (Keya Tasnim et al., 2024), the B-Prepared project aims to create engaging and effective learning experiences that foster greater resilience and preparedness among students.

2.2 Gamification in Learning

Gamification refers to the use of game design elements in non-game contexts and has gained substantial attention in education for its potential to increase learner engagement and motivation (Hamari et al., 2014, Deterding et al., 2011). In disaster preparedness education, where fostering practical skills and risk awareness is critical, gamification can support experiential learning by simulating realistic scenarios and encouraging active participation.

Serious games and immersive technologies such as video (Liu et al., 2023), or VR and AR allow learners to practice responses to hazardous situations in a safe environment (Boyle et al., 2016, Shaw et al., 2004). Prior studies indicate that interactive simulations can improve hazard recognition, decision-making, and procedural knowledge (Shaw et al., 2004, Radianti et al., 2020). Moreover, gamification elements, such as points, feedback, progress tracking, and scenario-based challenges, help sustain learner motivation and promote deeper cognitive engagement (Hamari et al., 2014, Deterding et al., 2011, Subhash and Cudney, 2018). For example, the Gamified Learning Theory (GLT) emphasizes that game attributes (e.g., challenge, rules, interaction) influence learning-related behaviors and attitudes (Landers, 2014). Effective gamification design can foster greater academic participation, enhance intrinsic motivation, and improve retention of preparedness knowledge (Hamari et al., 2014, Landers, 2014).

In the context of the B-Prepared project, gamification is a core pedagogical strategy embedded across the VR-prepared and IM-prepared applications. It utilizes scenario-based challenges, AR interactions, and multiplayer VR experiences to create engaging learning environments that encourage repeated practice and reflection. Integrating such tools into higher education curricula may help address existing gaps in disaster education and better prepare students for real-world emergencies.

3. Methodology

This paper is based on a single-case study, utilizing semi-structured questionnaires, and aims to explore integration pathways for digital disaster preparedness tools and methods in higher education contexts. The paper focuses on the possibility of developing an educational module that includes these components, which

can be integrated into a university curriculum. The technology utilized is inspired by the VR technology for the B-Prepared project.

The stakeholders' feedback was gathered through a small-scale questionnaire distributed to educators, students, and first responders. Three versions of the questionnaire were developed, each including a common core section (20 items for students and teachers, and 18 items for firefighters) focusing on general attitudes toward using VR for evacuation training. In addition to the core items, each stakeholder group answered specific questions related to their own role: educators were asked about their interest in integrating VR modules into curricula, students about their interest in VR-based training in courses, and firefighters about the relevance and validity of VR-based evacuation training. In total, responses were collected from 3 educators, 7 students, and 2 firefighters. The questionnaire included both closed-ended and open-ended questions.

The overall aim of the questionnaires was to capture perceptions of the potential benefits, challenges, and requirements for integrating digital disaster preparedness tools in academic settings as an educational module that can be adopted to different courses.

4. Results

The purpose of the survey was to gather initial feedback from stakeholders on the integration of VR-based fire evacuation training into university curricula. The survey explored three core areas: (1) current knowledge of evacuation procedures, (2) interest in using VR for fire drill training, and (3) preferences for training delivery formats. The following sections present responses from students, educators, and firefighters.

4.1 Student Responses

Students were asked to reflect on their current knowledge of emergency procedures and their interest in VR - based training. When asked about their knowledge of evacuation procedures, most students reported being familiar with evacuation signs; however, many were not fully aware of the location of the designated assembly points.

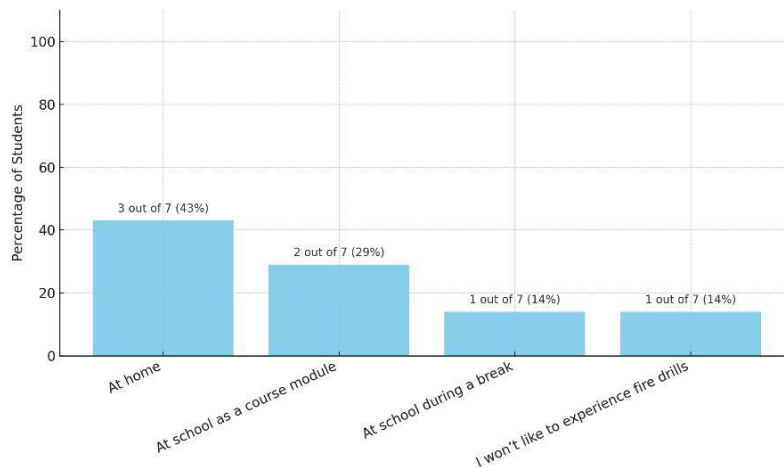


Figure 3: Student preferences for drill locations

When asked how they would respond upon discovering a fire, student responses demonstrated a range of preparedness. One student with a military background responded:

"Yell 'Fire!' so that people nearby know it's happening. Pull the fire alarm, then quickly check the nearby rooms. If it's not too intense, I might check the burning room too."

Another student shared:

"Get out, shout in the halls, find the fire alarm. If it's small, I might get an extinguisher first."

Regarding interest in VR-based fire drill training, six of the seven students expressed enthusiasm. Preferences for drill location varied: 43% preferred doing it at home, while others opted for a break at school or a course module (see Figure 3). The fact that most students favored completing drills at home or as part of a course module directly supports the feasibility of implementing flexible VR-based training scenarios, both for remote home-based practice and for integration as an academic module within university courses.

4.2 Teacher Responses

Educators were asked about their existing knowledge of evacuation, their interest in integrating VR-based training, and their ability to manage such training independently. All three educators reported that they actively look for evacuation signs when entering new buildings and indicated confidence in their basic evacuation knowledge and responsibilities in case of fire alarms.

All educators expressed support for incorporating VR-based fire drills into classroom activities, particularly during breaks, as a flexible alternative to traditional drills. However, when asked about their confidence in managing the VR-based training independently, all three educators reported a need for some form of support:

- One educator indicated that he/she would need personal VR training beforehand to feel confident in instructing students.
- Another educator mentioned that access to necessary VR equipment would be a prerequisite for implementation.
- The third educator highlighted the need for both equipment availability and ongoing technical support.

These findings indicate that while educators are open to adopting VR-based preparedness training, they emphasize the importance of providing adequate training, resources, and technical support to ensure successful integration into classroom teaching.

4.3 Firefighter Responses

Two experienced firefighters (with 7 and 30 years of experience, respectively) participated in the survey. They were asked about their perspectives on fire evacuation procedures and the potential role of VR-based training in supporting preparedness education.

Both firefighters emphasized that regular fire drills are essential for maintaining readiness among students and staff. They suggested that drills should ideally be conducted at least once every two years. Regarding evacuation behavior, they expected that, in the event of an alarm, students and teachers should safely gather at the assembly point and report any missing persons to responders if possible.

When asked about the potential value of VR-based training, both firefighters agreed that VR simulations could serve as a useful supplement to preparedness education. However, when discussing the possibility of officially validating VR-based drills, one firefighter commented:

“Yes—to see what is developed and evaluate it from my experience. But not to validate as to assure the quality of a VR application.”

This highlights that while emergency professionals are open to supporting VR-based training efforts, they prefer to contribute as consultants rather than serve as formal validators for the technological or pedagogical accuracy of the VR content.

5. Integration Pathway for Digital Preparedness in Higher Education

5.1 Proposed Integration Approach

Based on the findings of this study, it is evident that stakeholders, students, teachers, and fire safety professionals support the integration of virtual reality into school-based disaster preparedness training, as noted in prior studies (Hsu et al., 2013, Scorgie et al., 2024). However, enthusiasm alone does not guarantee institutional adoption. Practical implementation models are needed to support meaningful policy changes, focusing on knowledge, skills, and abilities (Abich et al., 2021), however, these aspects vary depending on the questioned stakeholders. The products in the B-Prepared ecosystem are designed to work together, offering multiple entry points for both educators and students.

Building on the B-Prepared ecosystem described above, one of the key objectives is to establish effective pathways for integrating these digital preparedness tools within higher education curricula. Rather than positioning the tools as stand-alone training products, the B-prepared project envisions their use as embedded components within existing university courses.

A practical pathway involves linking the RU-Prepared LMS with institutional platforms such as Canvas (a widely adopted LMS in higher education), allowing preparedness modules to be incorporated into standard course structures. This approach aligns with broader trends in the digitalization of higher education (Radianti et al.,

2020), the integration of serious games in the curriculum, and the use of learning analytics to support competency-based education (Ifenthaler and Yau, 2020) and disaster risk awareness (c.f. Calvet et al., 2019).

However, integrating such tools into academic curricula presents several challenges, including aligning them with existing pedagogical frameworks, ensuring institutional support, addressing technical integration with the university's own LMS, and fostering teacher readiness. Prior research highlights that educators often face barriers such as a lack of technical skills, institutional resistance, and uncertainties about pedagogical value when adopting immersive technologies (Calvet et al., 2019, Makransky et al., 2020). Effective implementation requires collaboration between content experts, pedagogical designers, and institutional stakeholders, but also considering the types of emergency (Liu et al., 2023).

The current proposal of this paper is to offer an optional learning module, a short module within existing university courses, rather than as a stand-alone subject. While the learning goals of a course are necessary, the components and ways of using parts of an ecosystem can be aligned with the original learning goals and can be demonstrated and illustrated by using the ecosystem, thereby enhancing learning and emergency preparedness. Examples include demonstrating concrete tool development issues from the B-Prepared products in programming courses, which can be followed by training using the constructed product. Using the concept of creating a knowledge management system through Disastropedia in management or innovation courses can also be followed by training with the B-prepared ecosystem. Since the B-prepared ecosystem encompasses various emergency preparedness issues, such a module can be incorporated into a large number of courses. In this way, digital preparedness can reach a broader student audience, including those in non-technical programs.

Since one of the main issues hindering eventual integration was considering the *User Flow*, from a student perspective, this is outlined as follows (see Figure 4):

- Students register for their regular university courses through the institutional LMS, e.g., Canvas.
- Within the Canvas course, they are offered a learning module on digital preparedness. (For this step, teachers' preparedness is necessary, not illustrated in Figure 4.)
- Ideally, via integration between Canvas and the RU-Prepared LMS, students would gain seamless access to the products, emergency challenges, and rewards in the ecosystem without requiring separate login credentials. (For this, the teachers need to choose suitable emergency management challenges and associated products for achieving their goals.)
- Once inside the RU-Prepared LMS, students access the connected B-Prepared tools via SSO, ensuring a unified learning experience.
- Student progress is tracked within the RU-Prepared LMS, and if the integration is fully implemented, selected progress data (such as module completion status) could be reported back to the Canvas gradebook.

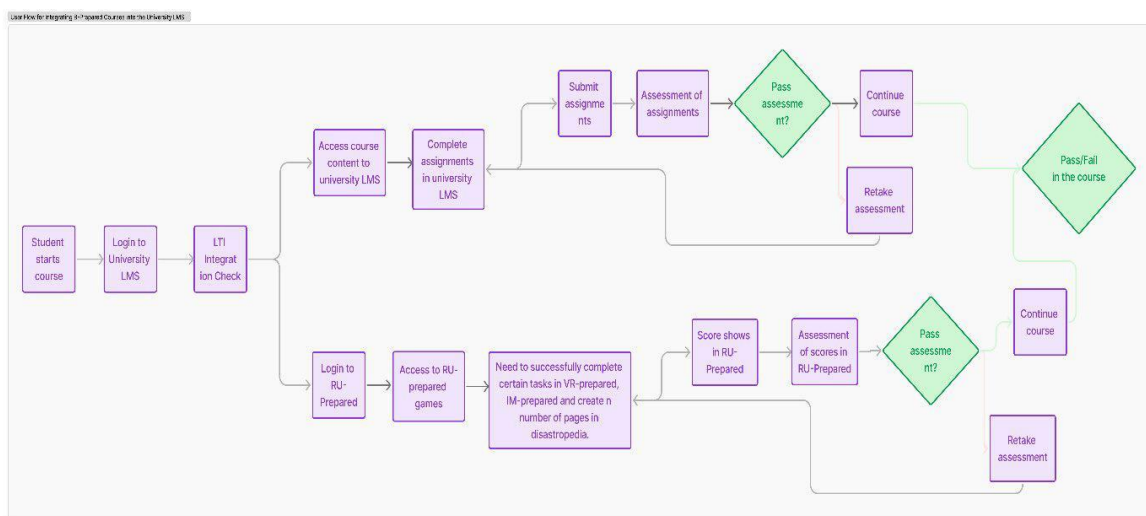


Figure 4: A student User Flow for integrating a B-Prepared module into a course. Full-resolution version available at: [Zenodo DOI link]

5.2 Technical Integration Option: Learning Tools Interoperability (LTI)

A central technical consideration for connecting RU-Prepared with institutional platforms, such as Canvas, involves Learning Tools Interoperability (LTI). LTI is an open standard developed by 1EdTech Consortium (1EdTech, 2025) that allows external learning applications to integrate directly into institutional LMSs.

In this model, the progress of the students could be synchronized back into the Canvas gradebook, provided the RU-Prepared system implements appropriate data mapping and reporting features. Since RU-Prepared already tracks task completions, quiz results, and badge achievements across its connected tools (VR-Prepared, IM-Prepared, Disastropedia), this data could potentially be made available for instructors inside the institutional LMS.

However, the actual implementation of LTI depends on several factors, including institutional policies, data privacy regulations, and long-term administrative support. Universities may hesitate to authorize full data exchange between external systems and internal student records due to concerns about privacy. If LTI integration is not feasible, instructors and students will need to maintain separate RU-Prepared accounts, and instructors may need to track students' progress outside of Canvas manually.

5.3 Challenges and Open Questions for Further use

Currently, the RU-Prepared LMS is based on Moodle. While Moodle–Canvas LTI integration is technically feasible and can offer a stable long-term connection, institutional support is still required for configuration, security updates, version compatibility, and long-term maintenance to ensure the integration remains functional as both systems evolve. This requires institutional support and long-term maintenance. It remains uncertain whether university -level IT services (e.g., HVL's IT department) will support this integration or whether the responsibility will fall to individual course instructors.

- If full LTI-based LMS integration is not implemented, students would need to create separate accounts in RU-Prepared. In this case, mapping student identities between Canvas and Moodle would require additional steps and may add administrative complexity for both students and instructors.
- Similarly, teachers would require teachers/educators accounts in RU-Prepared to monitor student progress. Without full integration, dedicated instructor dashboards would be necessary for teachers to track their students' progress.
- Ideally, if LTI integration is fully implemented, student progress data could be automatically synchronized back to Canvas gradebooks using student institutional IDs. In that scenario, no additional RU-Prepared accounts would be necessary for either students or teachers, thereby greatly simplifying the adoption process. The viability of this solution depends on institutional data privacy regulations, identity management policies, and IT service decisions.

The integration pathway presented here is an initial model that requires further validation and refinement. The next step will be to conduct pilot testing with students and teachers to evaluate both the technical implementation and the pedagogical fit within different university courses. Insights from such pilots will help refine the user flow, identify usability barriers, and inform institutional decisions about long-term adoption. Given that digital emergency preparedness is a relatively new topic in higher education, it is essential to ensure that the integration minimizes additional workload for instructors and supports them in aligning such approaches with curricular objectives. Continuous iterative development and stakeholder involvement will be necessary to achieve sustainable implementation.

6. Discussion

This study examined the feasibility and institutional considerations for integrating digital preparedness training into higher education curricula, incorporating stakeholder feedback and a proposed integration user flow diagram. The proposed integration pathway demonstrates how preparedness training via a module could be embedded into standard university course structures without requiring extensive redesign of existing curricula. By allowing such emergency preparedness modules to operate as optional components across diverse courses, even in non-technical fields, the approach may promote wider student access to resilience education.

In designing effective preparedness training, pedagogical factors remain central. Immersive technologies, such as VR and AR, offer valuable opportunities for experiential learning; however, their effectiveness depends heavily on scenario design and instructional alignment (Radianti et al., 2020; Makransky et al., 2020) and emergency procedures (Liu et al., 2023). Scenario-based learning environments must strike a balance between

realism and cognitive load; overly complex scenarios or excessive novelty may distract learners rather than support knowledge acquisition. Also, for successful curricular integration, the user experience must remain seamless and intuitive for both students and instructors. Fragmented or overly complex system flows can discourage faculty from adopting these modules in their courses (Ifenthaler and Yau, 2020). Long-term institutional commitment, including resource allocation for maintenance and staff development, is necessary to ensure the sustainability of immersive preparedness education (Ebinger et al., 2022).

Beyond the technical integration challenges described in the pathway, practical readiness for immersive technologies such as VR requires additional institutional considerations. Unlike the mobile-based or AR modules, the VR-prepared component demands access to VR headsets and dedicated physical space for safe interaction. Universities must ensure that both hardware resources and student support are available for effective implementation. While teachers may not need to directly operate VR tools themselves, especially if progress data is automatically reported, they still require a basic understanding of the technology to guide students and respond to potential technical or safety issues during training sessions.

Moreover, while the current approach focuses on higher education, similar integration strategies may also be adaptable to vocational schools or lifelong learning programs, broadening access to digital preparedness training across the broader population.

In future iterations, further collaboration between the project team, institutional stakeholders, and teaching staff is needed to refine the integration pathway. Pilot testing with selected courses and continuous feedback loops will help address practical barriers and enhance the value of digital preparedness training within university curricula. Future research should examine how students apply knowledge gained from immersive preparedness training and how institutional processes for integration evolve over time.

7. Conclusions

This paper explored integration pathways and challenges for embedding digital preparedness education into university curricula, focusing on serious games and immersive technologies developed within the B-Prepared project ecosystem. While national and institutional agendas increasingly emphasize digital resilience, effectively integrating it into existing academic structures remains complex, requiring both pedagogical and technical considerations.

The feedback collected from key educational stakeholders, namely educators, students, and fire safety professionals, indicates broad openness to incorporating such modules if challenges related to curriculum alignment, ease of use, and assessment processes are addressed. These actors represent core institutional stakeholders who would directly engage with or facilitate the use of such preparedness modules within their educational contexts.

We presented a concrete integration flow model for embedding B-Prepared tools into existing LMS environments such as Canvas, leveraging single sign-on (SSO) mechanisms to streamline access to multiple learning resources (VR, AR, and knowledge-based tools) for emergency preparedness. Ongoing collaboration with institutional IT services and academic staff is essential to ensure the smooth implementation and long-term sustainability of the project.

Future work should include pilot studies to test both the technical feasibility and pedagogical impact of digital preparedness across diverse courses and disciplines. Additional research is also needed to refine engagement strategies, particularly for less motivated student groups, and to develop robust assessment frameworks for measuring digital preparedness competencies. Broad institutional adoption will ultimately depend not only on technical solutions but also on building organizational capacity and fostering interdisciplinary approaches to digital resilience education.

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