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Constructing Seamless Learning Through Game-Based Learning Experiences

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ABSTRACT

The goal of this paper is to explore how game-based experiences can be leveraged through mobile technology to activate learner engagement and achieve a seamless connection between formal and informal learning. The paper presents a mobile game authoring tool that enables educators to create gamified lesson paths, drawing on the concept of atomic learning. Preliminary evaluation revealed three main findings. First, mobile games constitute a key driver in seamlessly blending informal, unguided learning that is driven by natural human curiosity with learning experiences which are driven by defined, formal learning objectives. Second, ensuring learning elements are suitable for direct use, and reuse, within game-based tools, requiring learning content with high granularity. Third, the success of gamified learning depends on visual and audio impact, along with an appropriate blend of challenges, rewards, learning content, and assessment units that form the narrative backbone.

KEYWORDS

Atomic Learning, Game Authoring Tool, Game-Based Learning, Gamified Lesson Paths, Learner Engagement, Mobile Learning, Seamless Learning

INTRODUCTION

Engaging learners, nurturing their interest, and igniting their curiosity and perseverance constitute perpetual challenges in education. These challenges become more evident in online, distant settings (Bolliger and Martin, 2018; Martin and Bolliger, 2018) and were further accentuated amidst Covid-19 pandemic. The rapid transition to remote education, social isolation, and mobility restrictions have fragmented the connections between learners, educators, educational activities, and learning outcomes

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(Piki, 2020; Piki, 2022). The unprecedented situation caused by the pandemic has also revealed various skills gaps for both students and educators. These challenges raise the need for adjusting, repurposing, and personalising learning content, student feedback, and assessment strategies; re-establishing student-student and student-educator connections; responding to social and emotional needs; as well as attending to the educational needs of learners with disabilities and underprivileged members of society (Brzezinska and Cromarty, 2022). Furthermore, there is an increasing emphasis on continuous re-skilling and up-skilling of both learners and educators to better prepare them for the 'new normal'. Alongside aptitude in technology-mediated communication and collaboration, demonstrating empathy and emotional intelligence becomes a key transferable competency. The Innovating Pedagogy 2022 report (Kukulska-Hulme et al., 2022) highlights the role of social media, mobile learning, and the role of emotions and wellbeing in new forms of teaching, learning, and assessment. Gamification and game-based learning are also increasingly utilised to motivate learners and enhance the learning outcomes (Zainuddin et al., 2020). These observations present a genuine opportunity for rethinking how to construct seamless, personalised, and engaging learning experiences in the post-pandemic era. Mobile and digital technology can play a pivotal role towards attaining these goals. Considering the ongoing changes affecting students' and educators' lives, the objectives of this paper are:

a) To explore how gamification and game-based learning can be leveraged through mobile technology to seamlessly blend formal and informal learning experiences.
b) To present a game authoring tool that enables educators to create mobile gamified lesson paths (GLPs) towards promoting learner engagement, interest, and curiosity.
c) To conduct an initial evaluation and identify the challenges and opportunities for future research and development in game-based learning.

BACKGROUND

A vast literature exists on educational gamification and game-based learning. This section discusses relevant literature on key concepts including gamification, playful learning and game-based learning; seamless and mobile learning; and microlearning. These concepts informed the design and development of the proposed tool for authoring mobile gamified lesson paths.

Gamification, Playful Learning, and Game-Based Learning

Learning through play is beneficial for both children and adults as it naturally evokes creativity, active exploration, imagination, and happiness rather than focusing on memorisation and performance (Ferguson et al., 2019). Gamified learning stimulates motivation, learner engagement, and social influence (Zainuddin et al., 2020), as opposed to optimising pedagogical design for pure functional efficiency (Chou, 2019). Gamification is portrayed as the craft of embedding fun and engaging elements that typically exist in games, to real-world activities (Chou, 2019) or non-game contexts (Zainuddin et al., 2020). The most adopted game elements include levels, points, badges, leader boards, and avatars, as well as mechanisms such as content unlocking, gifts, quests, social graphs, and certificates (Zainuddin et al., 2020). These elements encourage learners to achieve greater goal orientation, learn by repetition, but also engage in collaborative activities and friendly competitions with peers (Ding, 2019). Nevertheless, more emphasis is placed on enabling intrinsic motivation rather than extrinsic rewards (Cantuni, 2020). Gameful learning is associated with autonomous and constructivist learning emphasising authentic, meaningful, and active learning experiences (Ray, 2020; Rigby, 2014). Furthermore, gameful learning encourages tinkering and trial-and-error and supports learning from failure in a safe environment (Ray, 2020) – what Ferguson et al. (2019) refer to as 'positive or productive failure'. This entails learning in an environment which is flexible yet

scaffolded, and where learners are supported at the required level which is adjusted according to their needs and (dis)abilities.

Recent advances in mobile digital technology have heightened the applications of playful learning (Ferguson et al., 2019) and gamification in both educational and vocational training settings (Ștefan et al., 2019b). While the successful application of mobile games (Kapp, 2013; Moreira, et al., 2017), digital game-based learning (All et al., 2021), and educational gamification (Ștefan et al., 2018; Baalsrud Hauge and Ștefan, 2020) has been widely reported in the literature (Zainuddin et al., 2020), considerable gaps and challenges still exist, especially in relation to mobile game-based learning (Piki et al., 2020; Zainuddin et al., 2020). Although mobile technology presents generous opportunities for gamified learning, it remains a challenge for educators to create personalised gamified activities. Promoting inclusivity, adaptation, and personalisation entails considering individual characteristics, needs, requirements, and preferences (Böckle et al., 2017; Raleiras et al., 2020; Hallifax, et al., 2019), as well as diverse learning styles, approaches to studying, and engagement profiles (Piki, 2017; Piki et al., 2020), rather that applying the standard 'one size fits all' approach (Böckle et al., 2017). Simply employing a game or any other disruptive technology in the learning process cannot guarantee enhanced learning outcomes. Similarly, using extrinsic motivators such as virtual trophies or achievement points does not always ensure that students will be intrigued (Zainuddin et al., 2020). Therefore, any game or gamification element incorporated in instructional design must aim to purposefully engage learners (Piki, 2017) by employing appropriate motives, rewards, and feedback mechanisms (Adams, 2019). At the same time, while personalisation is key for increasing learner engagement, the time and effort educators need to invest for personalising content, feedback, and assessment is often unrealistic and daunting. This has important implications for educational game designers and developers who need to weigh up alternative options to mitigate the ineffective impacts of gamification in educational contexts (Zainuddin et al., 2020). These aspects were considered during the design of the proposed game authoring tool.

Seamless Learning and Mobile Learning

Seamless learning suggests that enhanced learning outcomes can be attained by bounding together various experiences (formal and informal, in-class and out-of-class, face-to-face and virtual, academic and non-academic, guided and autonomous, individual and social) so that that they appear as whole or continuous (Wong and Looi, 2011). While this concept has been around for decades, it has been prevailing in recent efforts to bridge curricular and life experiences towards re-engaging learners and mitigating the effects of the pandemic. Achieving a truly seamless learning experience requires bridging the strictly formal learning content related to a subject matter, with more informal learning activities involving collaboration with other learners and educators, contextualising learning, and moving beyond the walls of the traditional classroom (Wong and Looi, 2011). Seamless learning focuses on establishing continuity in learning and establishing holistic learning experiences. Merging formal and informal approaches and looking at 'the whole' student (mind, body, spirit, talents, experience, and knowledge) are the key enablers characterising seamless learning which has been associated with increased engagement and motivation, personal awareness, and behavioural changes (Wong, 2015; Hambrock et al., 2020). Mobile technologies constitute a suitable medium for seamless learning, given their inherent ability for supporting learning anywhere and anytime (Gikas and Grant, 2013; Zhang and Looi, 2011).

Microlearning and Atomic Learning

An emerging pedagogical approach, which fits well with the proposed game authoring tool, is that of microlearning or atomic learning (Leong et al., 2020; McKee and Ntokos, 2022). Pedagogies of microcredentials are founded on the philosophy of learning is small chunks (Kukulska-Hulme et al., 2022). Common features of microlearning-based approaches include fast learning pace, short duration of learning experiences (i.e., no longer than 10-15 minutes), topical relevance (i.e., focusing on a single definable idea or topic), and bite-sized chunks of learning content, also referred to as 'learning atoms'

or microcontent (Leong et al., 2020; McKee and Ntokos, 2022). Breaking the learning content down into relevant, bite-sized chunks makes it easier, more efficient, and more manageable for learners to grasp the core meaning. One application of microlearning is the segmentation of lecture recordings into taggable parts rather than uploading one continuous video. This approach saw renewed focus as a means of maintaining student engagement amid the challenging conditions presented due to Covid-19 pandemic (McKee and Ntokos, 2022). Another example is BBC's Bitesize, a free online study support resource for primary, secondary, and post-16 education in the United Kingdom, which includes guides, learning games and tools, as well as thousands of curriculum-mapped video clips, enhanced for use on mobile devices and 'learning on the move' (BBC Bitesize, 2022). Similarly, social, technological, economic, and other shifts in society engender a continuing demand in employability skills and upskilling in general. Microcredentials have emerged in the last decade in response to this demand (Kukulska-Hulme et al., 2022). Research has shown that microlearning has multiple benefits including promoting higher retention rate, improving learner engagement and motivation, increasing attention span, improving learning ability and performance outcomes, enhancing collaborative learning opportunities, as well as increasing learner confidence with the material (Leong et al., 2020; McKee and Ntokos, 2022).

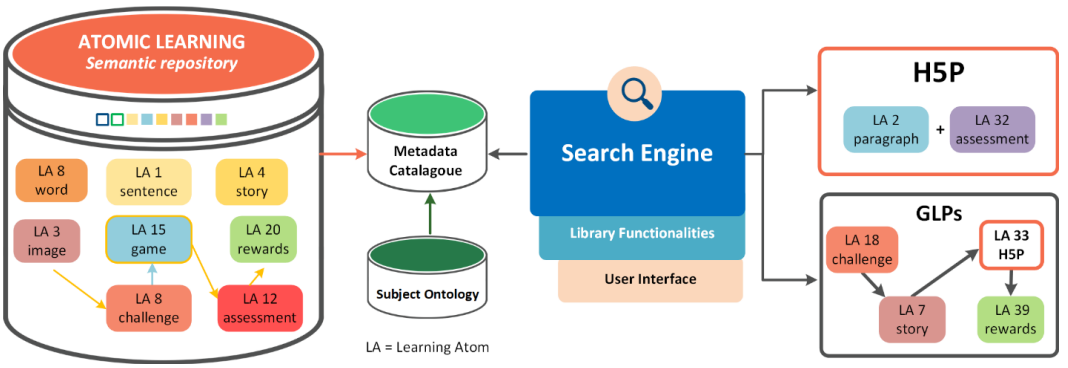
BUILDING GAMIFIED LESSON PATHS TOWARDS SEAMLESS LEARNING

Having considered the characteristics of game-based learning, seamless and mobile learning, as well as microlearning several appealing observations emerged. From a wider perspective, microlearning is akin to informal, unguided learning which is more likely to happen in authentic or multitasking environments. At the same time the characteristics of microlearning make it suitable and appealing for use in mobile game-based learning. Furthermore, the educational approaches discussed above share key qualities such as focusing on constructivist and autonomous learning, promoting self-efficacy, learner engagement and motivation, and increasing interest and curiosity-driven learning. Drawing threads from the educational constructs discussed above the Atomic Content Model is proposed as an approach for constructing seamless learning through game-based learning experiences (Ştefan et al., 2018).

Synthesis of Learning Principles – The Atomic Content Model

Game-based learning, microlearning, seamless and mobile learning constructs constitute the core pillars of the Atomic Content Model (ACM) (Ştefan et al., 2018). The model is based on ready-to-use, highly granular, scalable, and elastic content structures that can be mixed and reused across diverse learning scenarios, supporting the creation of games and gamified learning activities. The model aims to empower educators to adopt game authoring tools to easily create or customise games and gamified learning activities by utilising ready-to-use resources stored in a semantic repository (Fig. 1).

Figure 1. Atomic Content Model



The principle that lies at the core of ACM is that successfully achieving the learning outcomes entails providing the right content, in the right format, and at the right time and pace, to match fluctuating learning rhythm and knowledge intensity. Accommodating such needs requires a shift from fixed, non-customisable tools towards flexible applications that can be customised directly by end-users, in this case educators. When games and gamified learning activities are created by developers, they often provide limited customisation options to users. Thus, educators have limited opportunities to create or customise games and game-based learning activities to address specific needs and educational contexts. Authoring tools have emerged as a solution to ease the creation and customisation of games and game-based activities. However, the creation of game-based activities is a time-consuming effort, and the limited availability of adequate resources to support educators during the creation process greatly hinders the success of such endeavours. In this context, the availability of semantically searchable, ready-to-use, flexible and highly granular content that enables its use and reuse across a wide range of tools, including game authoring tools, has become critical. The ACM addresses this need – its implementation is supported by a semantic repository, coupled with a metadata catalogue supported by a subject ontology (Fig. 1). The repository stores granular content units (learning atoms) such as paragraphs, stories, images, sounds, as well as challenges, assessment metrics, and self-contained games, amongst others. Learning atoms can be directly used to create game-based learning activities, which can be stored autonomously or linked to other atoms, thus easing the authoring process.

Game Authoring Tool and Gamified Lesson Paths

The ACM is realised through a game authoring tool which enables educators to create mobile Gamified Lesson Paths (GLPs) exploiting the components of the model. The game authoring tool is implemented as part of the INCLUDEME (Inclusive Digital Environments to Enable High-Quality Education for Disadvantaged and Disabled Learners) project (2022), whose main goal is to construct novel and seamless learning experiences that engage, motivate, and increase the accessibility and inclusivity of learning resources for disadvantaged learners and learners with disabilities. The game authoring tool embedded in the INCLUDEME Platform provides educators with flexible ways to construct a game-based activity or lesson path, which can then be seamlessly blended with the curriculum. The educator can choose between developing simplified, standalone learning activities, or leveraging the seamless learning approach by designing mixed scenarios delivered as a GLP that is based on a story (narrative flow) (Ştefan et al., 2019a).

The narrative flow of the GLP is divided into three main types of screens: narratives, challenges (minigames), and assessments. The narratives aim to intrigue learners with the plot or storyline around which the GLP unfolds; the challenges aim to drive interest and curiosity-driven learning and motivate learners to seamlessly explore a flow of learning activities with varying level of difficulty; and the assessments can take diverse formats exploring available templates such as answering quizzes or solving puzzles. Challenges and assessments are associated with in-game rewards. A sequence of screens can be incorporated in a single GLP. However, the screens do not have to be incorporated in the GLP in a specific order or intensity. This gives educators the flexibility to choose which of the available resources (learning atoms) to utilise, and how to combine these, to better tailor the GLPs they develop having in mind their students' abilities and disabilities, and the learning context at large. Therefore, by utilising the game authoring tool, educators are not constrained by a strict predetermined process or route for constructing games; rather they can use workflow templates to create GLPs. The learner can, subsequently, carry out a search for a topic of interest or explore categorised topics (curiosity-driven scenarios) and choose a GLP with one learning atom or with several learning units. In addition to the game authoring tool, the INCLUDEME Platform incorporates a resource centre and a rich set of H5P (HTML5 Package) templates. This makes it easier and more efficient for educators to create, share, and reuse interactive learning content, including interactive videos, games, presentations,

quizzes, and other interactive Web-based content which is inherently mobile-ready. This content can be integrated in a GLP or used independently as a standalone H5P learning activity.

The following section provides an example of how GLPs can be delivered based on the underlying Atomic Content Model. Through a walkthrough scenario we discuss the capabilities of the Game authoring tool to deliver seamless learning experiences in mobile settings through games and gamification and, in turn, we conduct a preliminary evaluation with the view to identify the limitations and opportunities of this approach for future research and development in game-based learning.

A Walkthrough Scenario of a Gamified Lesson Path

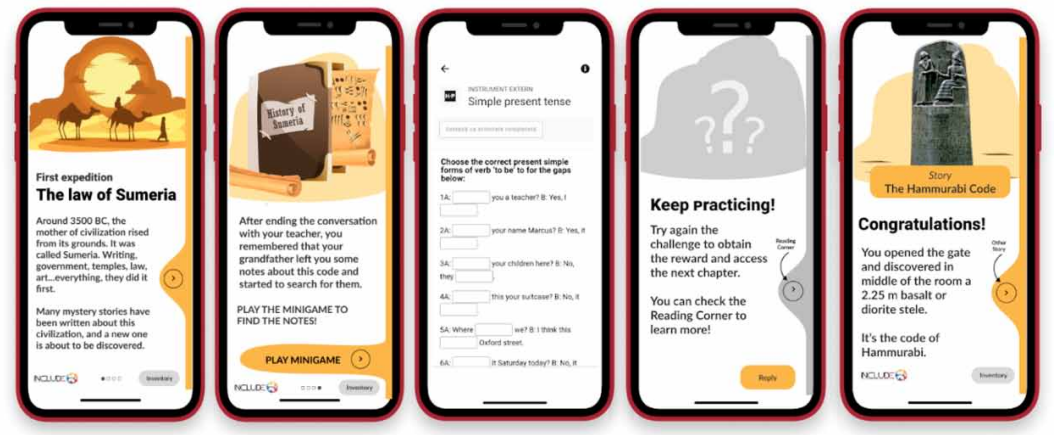
Every GLP revolves around a story which addresses a specific topic. The GLP presented below narrates through the story of the Hammurabi code, and includes both fictional elements that drive the game-based challenges and real facts that drive the learning processes (Fig. 2). The learning objectives of this GLP relate with language learning, in particular English grammar. The GLP incorporates screens with narrative content, challenges, as well as assessments and rewards.

As learners proceed through the gamified lesson path, they need to go through the narratives to be fully engrossed with the story. The lesson path drives learners through expeditions, quests, minigames, quizzes, encouraging messages, reading corners for further study, and encouraging and reward messages, amongst other elements. The narratives help seamlessly immerse learners into the story while also covering the required learning objectives. These narratives are followed by minigames, in the form of riddles or quizzes, to test the learners' knowledge and progress regarding various topics of English grammar (e.g., past, present, and future tenses, syntax, verbs, nouns, pronouns, adjectives, etc.). In the Hammurabi code GLP, learners need to proceed through four chapters with sequences of screens. The challenges at the end of each chapter take the form of minigames created with different H5P templates including fill in the blanks, mark the words, single choice quiz, and drag and drop image pairing. The first three chapters of the GLP are dedicated to simple present, simple past, and simple future tenses, respectively, while the last chapter assesses all of the above. Thus, the learner has the opportunity to review all the learning units.

Each GLP provides two options for interacting with learning content:

- *At GLP level* – The GLP presents the scenarios and minigames for the particular subject of study (e.g., grammar, syntax, punctuation, etc.). Any number of challenges can be presented to learners, and the level of difficulty can increase or be adjusted according to the learners' level,

Figure 2. An example of a GLP that reuses Learning Atoms



background knowledge, intellectual age, etc. The GLP is designed with the view to increase interest and curiosity-driven learning.

- *Outside of the GLP* – Learners can access additional information about the topic of the central story through reading corners or through resources such as wikis, blogs, articles from various publications, virtual museums, etc. In the final screen of the last chapter, the learners can also access a short story linked to the narratives of the GLP. In this example it is a story about the Hammurabi code. Access to the story is given as a reward while also encouraging further, unguided, self-directed learning and exploration.

The assessment and reward screen for each chapter includes the validation of the challenge and differentiates according to whether the answer provided by the player is correct or not. For a correct answer the screen provides the message congratulating the player, the reward (in the form of an image that is typically associated with the theme of the narrative), the option to check the inventory where the player can find the reward obtained, and possible clues for the next challenge, as well as the option to switch to another scenario or story. In case the answer provided is incorrect, the screen provides a relevant message, the replay button is activated encouraging the player to re-attempt the challenge along with the option to switch to another scenario or story. Each learner can go through the chapters at their own time and pace, and as many times as they wish aiming to improve their performance every time by reducing the number of wrong answers or completing the GLP faster. They can also work collaboratively in pairs or teams, or they can compete with their peers depending on how the educator decides to embed the game-based activity in the broader pedagogical approach.

PRELIMINARY EVALUATION, CHALLENGES AND OPPORTUNITIES

As part of the INCLUDEME project a piloting plan was developed reaching out to key target groups including teachers, learners with disabilities, and disadvantaged students. The purpose of organising the pilots was to conduct an initial evaluation of the platform under development and gather insights from the key target groups. This preliminary evaluation revealed three main findings which are discussed below.

Firstly, mobile games can enable the seamless fusion of informal learning experiences with formal learning objectives. Both the GLPs created with the Game authoring tool, and the rich set of H5P interactive content embedded in the games, are optimised for use on mobile devices. This enables learners to seamlessly engage with the learning content, and with each other, through their personal mobile devices. Nevertheless, the purpose of designing mobile GLPs is not to substitute traditional, guided instructional methods, but rather to enhance unguided, self-directed learning, and explore the concept of play as a fundamental medium of human learning. Hence, the focus is on exploration and playing and learning occurs as a side benefit of the gameful adventure. To this end, mobile GLPs represent an engaging and motivating way to support seamless learning approaches by stimulating interest and curiosity-driven interactions. They can also support learning at a distance and learning during emergency situations such as the rapid transition from classroom-based to remote education amid the pandemic.

Secondly, constructing learning units which are readily accessible and reusable within GLPs, requires learning content with high granularity. The ACM is based on the idea that all the elements of each GLP will be stored as learning atoms in a semantic repository. Similarly, it is expected that each GLP is also stored as a complete learning activity which can be shared or made public, duplicated, and altered to fit specific educational purposes based on the level of education, subject, or learning needs the educators identify. It is envisaged that such an approach will significantly facilitate the reuse of the multimedia, interactive content for generating new GLPs, H5P activities, or educational games. Nevertheless, although the underlying resources (i.e., content, images, H5P activities, videos, etc.) that make up a GLP, as well as the GLP as a whole, can be stored in the repository, achieving

a suitable level of granularity still remains challenging, as it depends highly on the quality of the content created by educators, as well as the way the content is organised, tagged, and stored in the repository. This observation highlights the need for formulating a systematic approach in developing the repository, as well as educators' training needs. Educators need to be trained both on composing GLPs and on maintaining a highly granular semantic repository with high-quality, reusable, and customisable learning atoms.

Thirdly, conducting initial pilots with teachers and students in the target groups, provided the opportunity to gather preliminary insights on several GLPs and H5P interactive activities created as part of a developing semantic repository of learning atoms. This preliminary evaluation revealed that successful gamified learning experiences depend on a blend of attributes including personalised challenges, customised rewards and assessment units, multimedia leaning content, and intriguing game narratives. Particular emphasis was placed on the need to incorporate content with visual impact, engaging animations, and immediate audio feedback. Currently, the Game authoring tool provides a set of predefined templates that educators can use to create or modify a GLP. The authoring tool enables educators to act as learning content creators assisting them in developing GLPs that can range from very simple learning units to complex stories that integrate storyline challenges, rewards, learning content, and minigames to assess knowledge acquisition. However, creating a GLP from scratch and discovering the perfect blend of challenges, rewards, learning content, and assessment units across a narrative backbone, still remains challenging. Therefore, achieving an engaging GLP is a challenging task, and more functionalities should be added on the authoring tool and the platform to support the authoring process, hence contributing to fully realising the ACM towards seamless learning. Further research is also needed to explore the perplexing factors that affect learning and learner engagement in mobile, game-based learning contexts, focusing particularly on learners with disabilities as well as disadvantaged learners.

Future work will focus on further developing the tool and on providing functionalities for automatic and semi-automated content refinement based on the ACM. The capabilities of the game authoring tool will be extended to better assist educators during the GLP creation processes.

CONCLUSION

Engaging learners with diverse characteristics, filling enduring skills gaps, and preparing learners for the everchanging world of work, constitute ongoing challenges in education. Coupled with these challenges, attending to the wellbeing and educational needs of learners with disabilities and underprivileged members of society is crucial. Considering the inherent attributes of mobile learning, atomic learning, and game-based learning, this paper explores how game-based experiences can be leveraged through mobile technology to activate learner engagement and help educators achieve a seamless connection between formal, guided instruction, and informal, unguided learning. The proposed approach builds on the following key premises: (i) play and playful learning can activate learner engagement, interest, and motivation; (ii) formal and informal experiences can equally contribute towards broadening the acquired knowledge and skills, enhancing user experience, and improving the learning outcomes; (iii) mobile devices constitute an efficient and effective learning medium for seamlessly delivering learning content and game-based learning experiences, (iv) empowering educators to create such experiences without being constrained by rigid, commercially developed games would widen the impact of game-based experiences; and (v) creating game-based activities requires that a rich set of resources in the form of learning atoms is readily available for educators. To this end, this paper presents a game authoring tool that enables educators to create Gamified Lesson Paths (GLPs) as an instrument that promotes self-directed and curiosity-driven learning.

The proposed approach focuses on atomic learning units which can be easily recombined, adjusted to fit various screen constraints, and re-modelled to match specific learning requirements

in a seamless way. As an instructional approach, the principles of microlearning and atomic learning focus on the design of relevant activities through micro content or micro steps combined in mobile, digital media environments. The beneficial characteristics of mobile and seamless learning, coupled with the inherent qualities of play, gamification and game-based learning are well aligned with the notion of atomic learning. These notions have collectively influenced the mobile Game authoring tool presented in this paper. An initial evaluation of the proposed approach was conducted drawing from preliminary insights gathered from educators and learners during piloting activities in the context of the INCLUDEME project with the view to identify the challenges and opportunities for future research and development in game-based learning.

From the educators' point of view, identifying content with high granularity makes it easier and more practical to use and reuse learning elements within game-based tools, hence making it more appealing as a complementary instructional approach. From the learners' point of view, the objective is to instigate interest, attract learner's attention, and improve their capabilities and skills development through game-based learning experiences, hence generating genuine upskilling and reskilling opportunities to better prepare them for the future.

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Conflicts of Interest

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