Developing Digital Accessibility and Inclusion Skills: A Gamification and Flipped Learning Approach

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Abstract: In this paper, a gamification approach combined with flipped lesson in a training program is described. The program was developed as part of the "InSIDE" Erasmus+ project on the Inclusion of Students with Impairments in Distance Education. The problematic was to find a modern approach and a suitable method to train students with various abilities and from different fields. We used flipped lesson and gamification methods to engage participants and create a more inclusive learning environment. Flipped learning approach is a teaching method that reverses the traditional sequence of instruction, where students first study the content on their own, then collaborate and interact with the teacher and classmates to reinforce and apply their learning. This approach can be particularly beneficial for students with disabilities who may need more time and support to absorb the material and engage in active learning. Gamification, on the other hand, involves the use of game design elements and mechanics to enhance motivation, engagement, and learning outcomes. It can be especially important for students with disabilities who may face additional barriers to learning and participation. The participants underwent training on how to incorporate and use accessibility features in documents, multimedia content, and Moodle platform. We start by breaking down the learning objectives into small, manageable chunks and designing activities that allow students to explore, practice, and apply the concepts in a fun and meaningful way. The practical exercises, inverse lessons, and gamification methods used in the training sessions were effective in engaging participants and creating a more inclusive learning environment. This paper highlights the importance of adapting suitable techniques to improve interaction between teachers and students, particularly those with visual, auditory, or motor impairments.

Keywords: Impairment, inclusion, gamification, flipped learning, accessibility.

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Introduction

Disability inclusion means providing individuals with disabilities, the opportunity to fully participate in all aspects of life, including education, employment, public health, and everyday activities. It involves designing products and environments with universal design principles, making them usable by everyone, regardless of their abilities. Presently, more than 1.3 billion people, which accounts for about 16% of the world's population, live with significant disabilities (WHO, 2023). Ensuring accessibility in education has become a pressing concern in order for students to have equal access and opportunities to learn and engage in the course material. As online learning has become the norm, many challenges emerged for students with disabilities in accessing digital learning resources. These challenges range from inaccessible content to the lack of awareness about the needs of such students.

For instance, individuals with visual disabilities relying on screen readers, may have a negative experience if the graphical contents are not well described. As for individuals with hearing disabilities, they rely mostly on visual cues and sign language to access information, and they often encounter challenges when it comes to auditory-based content. Consequently, captioning and sign language interpretation play a crucial role in ensuring accessibility for them. These accessibility measures are indispensable for enabling effective communication and equal participation of students.

One of the main problems faced by educators and trainers is the lack of knowledge about the proper application of accessibility elements, the specific pedagogical techniques and inclusion skills that should be used to enhance the learning experience of students, more so for students with impairments (Nieves Rivas Almaguer et al. 2022). In response to this challenge, new and innovative teaching methods and strategies are needed to promote digital accessibility and inclusion skills among learners. Among these approaches, gamification and flipped learning have emerged as powerful tools to motivate, engage, and educate students in an interactive and fun manner (Hamari et al. 2014).

Gamification involves integrating game design elements in non-game context as to motivate students to stay focused and engaged through fun learning (Deterding et al. 2011). Over the last decade, gamification has been increasingly used and promoted in education. One such example includes the Moodle Learning Management System, which is a popular open-source platform that is designed to facilitate online learning and course management. Moodle supports features and plugins that allow educators to incorporate gamification elements into their online courses (De Armas *et al.*, 2019), including: achievement badges, points and leaderboards, progress tracking, as well as quizzes and interactive activities.

Thus far, most studies reported positive outcomes from the use of gamification (Hamari et al. 2014). However, there is still a need to fully understand what types of gamifications are effective and in which specific context, more so in the case of students with impairments (Furini et al. 2019). As it becomes important to consider

learners' differences on perception of gamification and its accessibility, which can significantly impact the effectiveness of the learning approach.

With the objective of advancing understanding on how to apply gamification in the context of accessibility and inclusion, this paper describes and explains how we integrated gamification with inverse lessons to educate students in creating and using accessible documents, accessible math and video contents, as well as online courses in the Moodle platform. The training program was developed as part of the "InSIDE" project (InSIDE, 2020), an Erasmus European project on the Inclusion of Students with Impairments in Distance Education, unrolled at one of the partners universities, that is the University of Science and Technology Oran Mohamed Boudiaf (USTO-MB) in Algeria.

We start by providing an overview of the related work on teaching digital accessibility using gamification and flipped learning approaches. We then provide a description of the implemented approaches, practical exercises, inverse course, and gamification methods used in the training sessions, following the MDA framework (Mechanics, Dynamics and Aesthetics) (Hunicke et al. 2004), to explain the key aspects associated with gamification tailored to users' profiles. We conclude with a discussion on the limitations and future work perspectives.

Related Works

With the new generation of students known as digital natives, seeking more interactive and stimulating educational experiences, there is a growing need for more active educational methods (Dekhici et al. 2015). As highlighted by (Fernández-Raga et al. 2023), higher education institutions are dealing with significant changes due to digitalization and the effects of COVID-19 pandemic. Gamification and flipped learning approaches have become a popular strategy to engage students in non-gaming contexts. In this section, we will explore the latest research that investigated the application of gamification and flipped learning approaches in addressing accessibility concerns and promoting disability inclusion in education.

A comprehensive review conducted by (Hamari et al. 2014) outlined the empirical research on gamification, with a particular focus on its motivational affordances, psychological outcomes, and behavioral outcomes. On the other hand, (Furini et al. 2019) investigated the basics of designing a gamification approach tailored to the requirements of users of assistive technologies, that is understanding peoples' preferences and differences (either technological or physical). The study found that simpler rules are more preferred for those using assistive aids. Motivational components indicated a greater preference for points, levels, and collaboration in games.

In the domain of computer science and software engineering education, (Gasca-Hurtado et al. 2021) presented a software tool designed for gamified classroom experiences in software engineering education. The tool focused on students collaborating on software projects for people with disabilities and their families. Various gamification activities were employed to verify the achievement of learning objectives associated with the

experience. In a similar vein, (Lorgat et al. 2022) proposed a gamification-based approach to teach accessibility to undergraduate computer science or software engineering students.

The approach involved using introductory web accessibility videos and a gamified artifact presenting scenarios related to WCAG principles. For instance, students had to provide appropriate descriptions for displayed images as text alternatives, and a mouse dysfunctionality that encouraged keyboard-only usage. A similar study was presented by (Spyridonis et al. 2017). The authors proposed a framework using gamification to motivate web designers to learn about accessibility guidelines and increase their adoption in website and software development.

Other studies involving people with disabilities, (Ramos Aguiar et al. 2023) use gamification to teach blind individuals about Mexican currency, and aided individuals with autism spectrum disorder (ASD) in navigation using virtual reality, These case studies showcased innovative applications of gamification in improving accessibility and engagement for users with disabilities. (Yanfi et al. 2017) explored the use of gamification to help motivate and engage elementary visually impaired students, to learn how to type words, particularly those unfamiliar with computes.

Flipped learning is another approach where students prepare before class and collaborate during it, promoting individualized learning. (Thongkoo and Daungcharone 2022) implemented this method for university students in massive online courses. The results revealed that despite the course being delivered online, many students successfully passed the tests. In another study, (Daungcharone et al. 2023) applied flipped learning approach to modern management courses, examining how gender and learning behavior impact students' motivation and self-determination. (Hayashi et al. 2015) used a flipped classroom for teaching programming languages in computer science courses. Students prepared online, and class time was for teamwork. that a flipped classroom improved programming language learning and exam scores in computer science courses compared to traditional teaching methods.

The training program discussed in this paper was conducted during the 2022-2023 academic year at the University of Science and Technology Oran Mohamed Boudiaf (USTO-MB) in Algeria. The course comprised four sessions. The first two sessions focused on educating teachers and administrators about the importance of digital accessibility and inclusion in online learning and the ways in which accessible practices could be implemented. The subsequent sessions were designed for students with and without disabilities.

Gamification-based learning experiences were provided, using assistive technology tools to create an engaging environment for all students. Some of the encountered challenges were how to effectively communicate with deaf students, as teachers rely mainly on verbal communication. Delivering content to visually impaired students required creative solutions for conveying visual elements and core ideas. Additionally, identifying captivating themes and subjects to engage these students was also a challenge. These difficulties motivated us to develop our approach to inclusive education, which will be discussed in the following sections.

Methodology Modelling

In this section, methodology principles are outlined.

Flipped Learning Approach

In traditional classroom settings, students are often presented with information passively, leading to disengagement during class sessions. Inverse lesson or flipped learning (Hayashi et al. 2015; Daungcharone et al. 2023) is a teaching method that reverses the traditional sequence of instruction, where students first study the content on their own, then collaborate and interact with the teacher and classmates to reinforce and apply their learning.

Inverse lesson encourages students to take ownership of their learning and develop critical thinking, problem-solving, and collaborative skills. This approach can be particularly beneficial for students with disabilities who may need more time and support to absorb the material and engage in active learning. By combining gamification elements with a flipped learning approach, a powerful opportunity arises to address disengagement issues and rekindle students' interest in programming education.

Gamification Approach

Gamification is an educational approach that leverages elements and principles commonly found in video games to engage and motivate students in a learning environment (Deterding et al. 2011). It employs features such as points, badges, rewards, challenges, competition, and interactive experiences to make the learning process more fun, enjoyable and to encourage active participation. The aim of using gamification in teaching is to enhance student intrinsic motivation and overall learning outcomes by making educational content more interactive and stimulating.

The MDA Framework

There is a variety of gamification frameworks available, including the effectiveness of gamification (Kappen and Nacke 2013), the evidence-based framework (Berkling 2016), and the Mechanics, Dynamics, and Aesthetics (MDA) framework (Hunicke et al. 2004). In this work, we choose the MDA framework as it offers a comprehensive explanation of how these three essential components (mechanics, dynamics, and aesthetics) interact and support one another (Azmi et al. 2017).

The MDA framework introduced by (Hunicke et al. 2004) is a formal approach to understanding games making it easier for all parties to analyze, study, and create various game designs and game-related elements.

Table 1 describes the basic game elements adopted from the MDA framework within our approach.

Table 1. Description and mapping of game elements of the MDA framework in our approach

Category	Game Elements	Description
Mechanics	Quiz	An evaluation tool of the activities of the course
	Points	Are similar to marks
	Rewards	Rewards are physical or virtual goods such as extra points and social recognition to motivate the students (In our case, physical goods and participation certificates were used)
	Feedback	An immediate response to the activities and comments made by the students
	Badges	Labels given to the winners and can be lost during the progression of the game
Dynamics	Time-based system	Time constraints to create a sense of urgency and pressure for students to think and act quickly
	Progression and Achievement	After each level, questions must be more challenging than the previous one
	Competition	Seeking outperformance between and withing groups
	Team-work	Collaborative efforts and diversity in a group
	Self-expression	One person must explain to all the present the finding of his group
Aesthetics (Emotions)	Delight and thrill	Feeling of joy or satisfaction
	Surprise	Each step must have an element of surprise like a different reward
	Connection	No declared loser, and working to change the winning group at each step

Actors/ Involved Parties

Participants included both students with and without impairments (visual, hearing, and motor), along with the educator who facilitated the game. The students were organized into groups and the educator presented accessibility problems to solve, checked answers for completeness, and upfolded the rules and mechanics of the game. Students were permitted to use digital devices available for them to search for information, if necessary, as it is common nowadays for students to use their mobile phones, laptops, and other digital devices during class. Gamification seeks to leverage the use of digital resources to further motivate students to be more independent in their learning.

Mechanics

Game mechanics represent the rules and components making the gamified approach. They are responsible for rewarding users based on their achieved objectives, such as points, levels, challenges, gifts, and leaderboards. To enhance student engagement, a recommended approach involves challenging students to push their personal limits continually. This was achieved through the implementation of quizzes, constant feedback, offering mini challenges, and providing positive reinforcement. By creating such a motivational atmosphere, students were encouraged to strive for improvement and actively participate in their learning journey. Badges and rewards were also used to represent accomplishments, in our case they were in the form of physical goods and participation certificates. These rewards offer various benefits, such as motivating students, providing recognition of their status, and serving as tangible evidence of their achievements.

Dynamics

Game dynamics address users' needs and desires that can be fulfilled by utilizing game mechanics, leading to improved practices in the workplace through rewards, status, achievements, and self-expression. We restricted activities by time limits as a motivation action since the game is designed to practice programming concepts in a computer science course. Also, adding the time component forces students to act quickly and intelligently, a crucial skill for timed exams. The game was turn-based, allowing all teams to tackle the problem within a certain time period. Upon solving a problem, a team is promoted on the leaderboard and no penalties were imposed for failing to solve a problem. Competitive game elements serve the purpose of instigating a sense of competitiveness among students, motivating them to strive for excellence individually. Collaborative elements involve working together as a group towards earning points and assisting each other in accomplishing shared goals. By combining both competitive and collaborative aspects, the experience was further enriched, promoting healthy competition while also nurturing teamwork and cooperation among students.

Aesthetics

Aesthetics refer to the overall emotional experienced. Emotions in the framework aim to cultivate a sense of delight, thrill, and surprise among participants. Delight was fostered through emotional engagement and applause. Thrill is introduced to infuse excitement, while each step features a distinct reward to maintain intrigue. Moreover, the approach promotes a sense of connection by ensuring that no group is declared a loser, striving to alternate the winning group in each step, thus emphasizing inclusivity and collaboration.

Methodology Implementation

In this section, we explain the practical application and implementation of the proposed approach.

Selection and Configuration of Digital Tools

Decisions were made concerning the use of projectors for presentations, which played a crucial role in delivering educational content for deaf students but needed to be avoided for blind individuals.

Group Preparation for Diverse Participants

Groups of players were thoughtfully constructed, ensuring a diverse composition that encompassed trainees with varying abilities, including those with and without impairments, as well as students and teachers. The intention was to foster an environment where participants could complement one another's experiences.

Granular Learning Objectives Breakdown

Learning objectives were meticulously disassembled into smaller, more manageable chunks, allowing for the design of activities that facilitate students' exploration, practice, and application of concepts in an engaging and meaningful manner. The participants underwent training on how to incorporate and use accessibility features in documents, multimedia content, and Moodle platform. For example, when it came to ensuring that documents, such as PDFs and Word files, were accessible to individuals using screen readers, the content was broken down into smaller modules. This involved incorporating proper headings and providing alternative text for images

Imposing Constraints for Challenge

To enhance the challenge within the game, specific constraints were introduced such as time limit.

Comparative questions Elements

For students with visual impairments, questions revolved around the identification of the most suitable screen reader, while for auditory impairment students, the focus was on tools for video captions and personal experiences with movies lacking captions. The evaluation of these questions required groups to convincingly present their findings to trainers and peers.

Leveraging Hobbies and Critical Thinking

Certain questions were designed to capture the attention of trainees and stimulate critical thinking. For instance, participants were first asked about their preferred types of games before being prompted to establish criteria for accessible games tailored to various disabilities. Most of them ignore the existence of platforms that offer game versions according to their needs.

Incorporating Guessing Questions

To enhance engagement, guessing questions were incorporated. Participants were presented with clues incrementally to deduce answers. As an example, they were asked to identify a social network designed for the visually impaired, that recently collaborated with an AI company to replace human volunteers with bots. It's important to note that a single round of this guessing game can yield many hidden insights.

Collaborative Atmosphere with Cyclic Success

Within the framework of each level, the gamified flipped lesson emphasized the concept of fostering a collaborative atmosphere while introducing an intriguing twist to the competition. In every level, one group emerged as the winner, but the instructors worked diligently to maintain a cyclic pattern of success among the various groups. This approach aimed to ensure that each participant had the opportunity to experience victory and receive rewards at different levels throughout the course. The design intentionally embraced the notion of "many winners" by orchestrating a dynamic rotation of successful participants, reinforcing the inclusive spirit of the learning environment, and encouraging active engagement from all participants.

Rewards and Incentives

Participants earned points upon successful completion of each level, and they received valuable feedback and rewards for their progress. Rewards were meticulously selected to align with the interests of the trainees. For instance, visually impaired students showed a preference for rewards such as scented items (e.g., soap, deodorants, gums). Applause served as a particularly effective form of moral reward and recognition.

Discussions and Results

Students with impairments shared their daily life and learning experiences, including aspects like gaming, watching subtitled movies, and addressing learning and transportation challenges. Both students and teachers without impairments initially learned from their peers with disabilities and continued to gain further insights through class discussions. The integration of gamification techniques notably increased participant engagement and created a more inclusive learning environment. Flipped learning methods effectively managed time constraints and proved to be beneficial. An overall satisfaction test was administered, with the majority of participants expressing satisfaction. Future work will focus on objectively quantifying the impact of the proposed approach on student learning and assessing its scalability with larger class sizes.

Conclusion

We've combined inverse teaching with gamification to help students learn about creating accessible contents including accessible documents, video creation, math equations, and engaging in non-visual social media. Our approach starts by breaking down the learning objectives into small, manageable chunks and designing activities

that allow students to explore, practice, and apply the concepts in a fun and meaningful way. Students earn points for completing each step and receive feedback and rewards for their progress. This approach has been successful in teaching digital accessibility and inclusion skills to both teachers and administrators. The application of practical exercises, reverse course delivery, and gamification methodologies has been observed to stimulate active participants engagement and contribute to the establishment of a more inclusive learning environment. Despite the significant achievements, it's important to acknowledge the presence of some challenges, including the need to adapt teaching methods to cater to students with diverse disabilities and the logistical complexities surrounding technology and resource accessibility. To ensure continued success, there is consideration for extending training durations and implementing enhanced support structures for participants, all aimed at guaranteeing the availability of essential resources, alongside the suggestion of designing digital or printed accessible game boards.

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