Gamification in work-based learning in vocational education to support students' coding abilities

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Article Info

Article history:

Received May 1, 2024
Revised Sep 16, 2024
Accepted Sep 30, 2024

Keywords:

Coding
Gamification
Pedagogical
Vocational education
Work-based learning

ABSTRACT

This article studied the integration of gamification in work-based learning within vocational education as a means to support students' coding abilities. By applying game mechanics such as points, badges, leaderboards, and challenges, we aimed to motivate and engage students in coding activities that mirror real-world industry practices. The inclusion of gamified elements into the curriculum was designed to make the learning process more interactive, fostering a competitive yet collaborative environment that enhances students' interest and perseverance in coding tasks. This research employed a quasi-experimental design with pre-test and post-test measures to assess the impact of gamification on coding proficiency, comparing the outcomes of students participating in gamified learning environments with those in traditional settings. The findings indicate a significant improvement in the coding skills of students exposed to gamified work-based learning, suggesting that gamification can serve as an effective pedagogical tool in vocational education, better preparing students for industry demands.

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1. INTRODUCTION

A learning approach that has been widely used in various countries around the world in the last few decades is work-based learning (WBL). Refers to constructivist learning theory, which demands active, dynamic, and lifelong learning by students [1]. WBL is very suitable for vocational education that emphasizes technical or practical education [2]–[4]. WBL is a form of learning related to all types of work, workplace-based learning, workplace learning, and learning through work [5]. Several studies show that WBL is a program designed to integrate higher education with the industrial world by providing opportunities for students to study in the industrial world [6]. WBL provides students with the opportunity to gain experience in higher education and then apply their skills in the industrial world in their field of study with the competencies needed in the world of work [7]. The use of WBL in higher education gives students work experience like they will get in real jobs in the future. This can make students quickly adapt to learning in college and the real work environment, so they can choose a career that suits their interests [8]. Researchers see WBL as different from conventional training, where WBL involves direct involvement and provides real-world experience in the workplace [9], [10].

WBL also provides students with the opportunity to have special competencies that exist in the industrial world and allows them to increase their competencies to a higher level through special learning.

WBL is learning that occurs in the workplace and takes over the roles played in the workplace [11]. This is because WBL is a learning strategy that utilizes the work environment as a means to transfer knowledge.

The WBL program had a positive impact on student performance on state standardized tests in New York [12]. Less successful and less college-oriented students were more interested in the WBL experience and also noted that there were fundamental methodological problems faced by school superintendents evaluating relationships between schools and the industrial world to the extent that observed student outcomes could be attributed to the program activities or characteristics [13]. Increased student academic achievement through participation in a WBL program when they completed case studies and collected qualitative data in Toronto, Ontario, Canada, from 1996–2001 [14]. There is a link between students' participation in WBL and their success in postsecondary education, but the data they used came from only two counties in Michigan, and the researchers noted that more evaluation studies are needed to fully understand students' WBL experiences [15].

The research cited above provides insight into the relationship between students' participation in WBL programs and their potential for academic success. However, previous research was conducted in locations with very different population densities, school/district types, WBL program structures, student demographics, and political policies compared to current conditions. Using the Work-Based Learning Policy 50-State Scan report [16]. There are two categories of states from previous research: (1) states that they have policies for high schools to receive financial support to implement WBL programs, and (2) states that they did not provide WBL funds to high schools. Learning does not need to be limited to taking knowledge from a formal and structured format. The WBL method is a very effective way of learning because it emphasizes reflection on work practices [17]. Perhaps the best solution is learning to acquire the skills and knowledge they need effectively [18], [19]. In this study, we compare traditional teaching approaches involving classroom lectures with the implementation of gamification which plays a role in increasing engagement levels, as well as helping students in their learning more efficiently. To our knowledge, this is the first academic research project to apply a gamified approach in an educational context.

2. LITERATURE REVIEW

2.1. Gamification

Particularly in the present technology era, gamification is a notion that is gaining popularity and impacting business professionals globally [20]. Gamification is the process of reducing target audience disinterest by utilizing components of game design in non-gaming environments. This makes it easier to incorporate already-existing content, such as webpages and makes game dynamics more visible to boost user productivity [21]. By simulating playing a game, gamification extends the range of knowledge that may be gained from tasks that are directly related to the game and ultimately boosts user motivation, satisfaction, and productivity [22].

Game development experts have a knack for finding interesting techniques to keep audiences engaged. Gamification has been rapidly adopted in various business, management, marketing, and ecological initiatives [23]. After recognizing the effectiveness of gamification, educators began implementing it in the classroom environment. Currently, teaching strategies that utilize gamification are used to activate the learning process for students. Gamification has become one of the learning technologies that has emerged and is widely accepted in the world of education today [24]. This is because the learning approach resembles a game with rules, levels, and even rewards. In this context, students must follow rules to advance to the next level and ultimately receive rewards, such as high ratings or praise from teachers. By integrating game elements into teaching, students become engaged by acquiring higher-level tasks or challenging other students [25]. To create a teaching environment that is more game-like and engages students, educators can see user-level concepts, provide challenges, provide second chances, allow students to make choices, and provide rewards and badges. In academic environments, gamification is carried out on the belief that it supports and motivates students, which in turn can improve learning outcomes [26].

2.2. Work based learning

A learning program or style that draws directly from issues and events that arise in the workplace is known as work-based learning [27]. To teach students and guarantee that they fulfill the demands and specifications of the occupations they encounter, this method combines conceptual theory with practice, knowledge, and experience [28]. Argues that work-based learning has several advantages for firms, including:

- Work-based learning can boost an organization's level of creativity and productivity.
- Work-based learning is a highly successful pedagogical approach.
- Work-based learning contributes to employees' improved professional growth.

– Work-based learning plays a significant part in raising the standard of vocational instruction and training.

For over twenty years, students and staff in a variety of organizations have successfully developed job skills through work-based learning [29]. This strategy makes sure that newly graduated college students successfully transfer the skills required in the workplace and helps close the knowledge and skill gap between the academic and professional environments [30]. However, currently, work-based learning still faces challenges that hinder the smooth flow of learning in the world of work, especially when the focus is on new graduates [31].

In information processing theory [32], knowledge and skills are initially stored in sensory memory during learning, which filters information by shifting the most important ones to working memory, the next stage. To encode information impressions and store them as imagery, procedural memory, or semantic memory in long-term memory, working memory is a subset of short-term memory [33]. When a learning job surpasses our ability to process memory, a condition known as cognitive overload may arise due to a limited capacity for working memory. Cognitive overload can result in difficulties in filtering, selecting, and analyzing existing information, which ultimately affects learning effectiveness and increases anxiety when studying [34]. In addition, high cognitive load in work-based learning can reduce student engagement, reduce independent learning abilities, and affect overall learning outcomes [35]. However, increasing cognitive load can improve learning in work-based contexts [36]. Indicated that technology adoption can create a more efficient work environment, helping employees develop better cognitive skills at work [37].

2.3. Gamification and work-based learning

Computer-based training is identified as one method of WBL [38]. This approach helps employees engage with routine tasks, predict potential failures, and ensure that their skills match the needs of the work they undertake [39]. Therefore, the application of gamification has become widespread in various work environments and industrial sectors [40]. In the manufacturing sector, design training using computer-assisted design (CAD) proves the effectiveness of using gamification in increasing efficiency [41]. In the healthcare field, several physical, cognitive, social, and emotional benefits from using gamification to support elderly care. Additionally, in the context of the public sector, the use of gamification has been proven to be able to overcome complexity in procurement and employee training processes [42].

According to research, gamification presents an opportunity for creative and beneficial ways to support organizations in enhancing the work-related knowledge and abilities of their workforce. Additionally, this strategy promotes vitality, loyalty, and staff involvement [43]. However, it is unfortunate that research using gamification for work-based learning purposes is still limited [44]. However, Buligina and Sloka [45] stresses that gamification is an effective training technique that can successfully meet the training and educational objectives established for the workplace while overcoming a variety of obstacles in work-based learning.

Gamification has several advantages in learning for students [46]. Adult learning approaches should allow individuals to control their learning process, recognizing individual differences in terms of their schedule, location, and pace of learning. This condition can be easily met through the use of gamification, which allows participants to choose how, when, and where they complete their learning. Furthermore, learning becomes easier to access when it is divided into smaller, more manageable components, like subskills [47]. In this context, gamification uses game elements to complete different parts of training, resulting in a transformation of knowledge for participants and making training more accessible without causing difficulties. Finally, gamification gives control over learning content to participants, providing flexibility in learning settings [48].

3. METHOD

3.1. Gamification design

From literature research and teaching experience in programming languages, the training system uses a gamification approach and presents a series of games. This system aims to help students who have no experience in programming languages. We integrated the principles of Kolb's learning cycle theory [49] that we had reviewed in the literature into the play experience.

- The first step taken is to provide students with an introduction to the basic concepts and knowledge required.
- Next, students try the activities that have been explained to themselves to gain experience.
- Demonstrate how to use games correctly so that students can understand them.
- Students are allowed to study and then draw their conclusions, as well as gain experience and summarize the knowledge they have gained.

– Students try the games themselves that have been explained and demonstrated to try out direct experiments.

The game used is adapted CodeComat. This game provides a game that can hone students' coding skills. The following is an illustration of the adapted game. The uploaded image shows Figure 1 the interface of the educational game CodeCombat, which is designed to teach the basics of programming through game concepts. In this display, you can see a level map with various areas, such as the Kithgard Dungeon which is open to play, as well as several other levels which are locked. Each level has a specific learning category, such as web development and game development, which teaches concepts such as HTML, scripting, and game design. The "Play" button allows the player to start the first level, with information about the number of challenges to complete. At the bottom, there are options to log in or register, while in the top right corner, there is information about the classroom version of CodeCombat which offers additional features for teachers and students. This image illustrates how CodeCombat combines game elements to make learning programming more interactive and engaging.

Figure 1. Game main menu

This image shows Figure 2 what the Kithgard Dungeon level looks like in the educational game CodeCombat. Here, players see a complex underground maze map with various obstacles, paths, and rooms to explore. At the bottom left, there is a yellow arrow that shows the starting point of the player character. Players must navigate their characters through obstacles and challenges within the dungeon to progress to the next level, completing programming tasks. At the top, you can see the level status which shows progress with the numbers 0/44. The interface at the bottom of the screen also displays options for logging in, registering, and accessing other features such as inventory and settings. This image reflects the interesting visual aspect of CodeCombat, where learning is combined with exploration in the game.

Figure 2. Initial game start

This image shows Figure 3 the Inventory screen in the CodeCombat game, where players can see their character and the equipment they own. On the left side, you can see the main character who can be customized with various equipment such as clothes and weapons, although in this image the character is not equipped with any equipment. In the middle, several items are still locked, indicating that players will need to progress further in the game to unlock or obtain these items. At the bottom, there is a "Change hero or language" button to change the character or language, as well as a "Play" button to continue the game. This interface helps players manage their character's equipment before moving on to the next challenge.

Figure 3. Characters in the game

The images shown Figure 4 are part of the CodeCombat game process, which focuses on the player's interaction with in-game characters and inventory. At this stage, the player selects and customizes the character with the available equipment before starting the next challenge or level. In the CodeCombat game process, players have to complete various missions by writing codes that direct their characters to move, fight, and solve puzzles. Every decision made on the inventory screen, such as choosing an item or changing a character, will affect the character's abilities and strategy in facing obstacles in future levels. This interface is an integral part of the gameplay that combines programming learning with dynamic gameplay.

Figure 4. Game process

In a CodeCombat game for example Figure 5, when the “Mission complete” screen is displayed this means that the player has finished the mission or level in play. This screen normally contains details on the completion of the mission for instance the numerical success such as points earned or bonus points among other features that entail time taken to complete the mission and the number of tries or faults made. They may be allowed to progress to the next level of gameplay, replay to the same level to enhance certain strategies or go back to the main map to select another level of challenge. The "Mission Complete" motivates the players to continue the gameplay and enhance their programming skills at the same time.

In the CodeCombat game, the "Mission Complete" screen indicates that the player has finished the mission or level in play. This screen provides detailed information such as points earned, bonuses, time taken to complete the mission, and the number of mistakes made. Players can either progress to the next level, replay the same level to refine their strategies or return to the main map to choose another challenge. The "Mission Complete" feature serves as motivation for players to continue gameplay while simultaneously improving their programming skills.

Figure 5. Game complete

3.2. Population and sample

The population used in this research consisted of five classes consisting of 150 vocational education students majoring in informatics engineering education at Padang state University in the first semester who had different educational backgrounds, namely high school, vocational high school, and Madrasah Aliyah. Next, to determine whether students have the same abilities, a T-test was carried out, and it was found that two classes had the same average initial abilities, namely 60 students.

3.3. Training procedures

The training program in programming education is conducted using two approaches: in-class training and game-based learning. To structure the programming design training, the steps outlined below ensure a comprehensive learning experience. Table 1 illustrates the training procedures, detailing the time allocation, tasks, and assessment methods for each approach. The focus is on providing students with both guided and independent learning opportunities, ensuring that they can apply their knowledge while also reflecting on the experiences gained throughout the learning process.

Table 1. Training procedures

Approach	Task	Assessment
Two hours of virtual learning per lecture for 16 weeks, totaling 48 hours	Tasks at each meeting, and rewards are given for each task completed.	Reflect to students what experiences they gained during learning.
The six hours of virtual learning focus on the game itself. This session includes a guide on how to use the game, installation steps, and information on how to contact us if you have questions or need help.	To provide freedom for students to study independently, the time must be 48 hours, and the system will record the time.	Reflect to students what experiences they gained during learning.

4. RESULTS AND DISCUSSION

4.1. Data analysis

To calculate the mean, standard deviation, maximum, and minimum scores, a description of the data is required. On the other hand, inferential statistics are used to assess variations in learning outcomes among different learning styles of students. Before conducting the analysis, homogeneity tests, specifically Levene's test, were used to evaluate the equality of variances. Next, to determine the learning outcomes between the control group and the experimental group, a test was used. Table 2 provides an overview of the student demographics involved in the study, covering key factors such as gender, educational background, and age distribution. The data is presented to highlight the diversity within the student population, offering insight into the composition of participants. This demographic information helps contextualize the results and outcomes of the research, ensuring that the findings are interpreted with consideration of the participants' backgrounds.

Table 2. Student demographics

Demographics	Student presentation
Gender	
Woman	45% (n=27)
Man	55% (n=33)
Educational background	
Senior high school	78.3% (n=47)
Vocational school	16.6% (n=10)
Senior high school	5% (n=3)
Age	
18 years	86.6% (n=52)
19 years old	8.3% (n=5)
20 years	5% (n=3)
Total	100% (n=60)

4.2. Comparison of two groups

To distinguish the differences between the two study groups, we ran an independent sample t-test. Our initial criteria in this research were how long students spent studying and assessing the assignments that had been given to them. Some of the group A students did not spend 48 hours studying virtually, while group B studied for six hours virtually, and the rest played and studied independently. Table 3 shows the average hours spent by students in learning, with group A taking part in virtual learning and group B taking part in game-based (gamified) learning. The time spent studying by group A varied between 34 and 48 hours, indicating that some students in group A did not complete the entire duration of their study. Meanwhile, in group B, it ranged from 45 to 52 hours, which is higher than the figure in group A.

Table 3. Total time attending the learning in the gamified

	Total of students	Min. hours	Max hours	Range	Mean	Std. deviation	Std. error	Variance
Total time used in learning. virtually group A	30	34	48	14	42.38	3.55	0.45	12.61
Total time used in learning game-based B	30	48	52	12	49.70	2.69	0.34	7.26

Table 3 shows the time spent by two groups of students in the learning process, namely virtual group A and game-based group B. Each group consists of 30 students. The information displayed includes minimum and maximum time spent by students, as well as various statistical measures such as mean, standard deviation, standard error, and variance. In the virtually group A group, students spent a minimum of 34 hours and a maximum of 48 hours studying, with a period of 14 hours. The average time spent was 42.38 hours with a standard deviation of 3.55 hours. This shows that study time in group A tends to vary quite significantly. The standard error for this group is 0.45 hours, while the variance reaches 12.61, indicating a fairly large level of data spread.

Meanwhile, the game-based group B group showed higher study time, with a minimum of 48 hours and a maximum of 52 hours, resulting in a period of 12 hours. The average study time for this group is 49.70 hours, which is higher than group A. The standard deviation of 2.69 hours and standard error of 0.34 hours indicate that the study time in group B is more consistent and less variable than in group A. The variance in group B was recorded as 7.26, which is also lower than group A, indicating a smaller spread of data. From this data, it can be seen that group B spent more time studying with smaller variations, which may reflect differences in learning methods used between the two groups. Group B which uses game-based methods seems to be more consistent in allocating study time compared to group A which uses virtual learning.

Table 4 displays the results of an independent sample test (Independent samples test) to compare the time spent by group A and group B in learning. Levene's test for equality of variances shows an F value of 1.691 with a significance (Sig.) of 0.196, which means that the variance between the two groups is not significantly different (p>0.05), so the assumption of equality of variance is acceptable. The results of the t-test for equality of means show t of -10.690 with degrees of freedom (df) of 118 and a two-sided significance value (Sig. 2-tailed) of 0.000, which shows a significant difference in time averages between group A and group B. The difference in mean time spent was -5.8 hours, with a 95% confidence interval between -6.87 to -4.72 hours, indicating that group B spent significantly more time studying than group A.

Table 4. Independent samples test spent hours of group A and B

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% Confidence interval of the difference	
									Lower	Upper
Hours	Equal variances assumed	1.691	.196	-10.690	118	.000	-5.80000	.54254	-6.87438	-4.72562
	Equal variances not assumed			-10.690	114.402	.000	-5.80000	.54254	-6.87473	-4.72527

Table 5 compares learning outcomes between two classes, namely class A and class B, each consisting of 30 students. Class A has a minimum score of 65 and a maximum of 70 with a range of 23, an average score of 77.83, a standard deviation of 7.08, a standard error of 1.292, and a variance of 50.14, indicating that there is quite a large variation in scores between students. In contrast, class B recorded a higher minimum value of 88 and a maximum of 98 with a range of 28, as well as a higher average value of 83.53, a lower standard deviation of 5.91, a standard error of 1.080, and a variance of 35.01. which shows that students in class B not only achieve better but also more consistent learning outcomes compared to class A. Overall, this table shows that students in class B achieve higher and more stable learning outcomes compared to students in class A.

Table 5. Assessment of student learning outcomes

	Total of students	Min.	Max.	Range	Mean	Std. deviation	Std. error	Variance
Learning ourcome class A	30	65	70	23	77.83	7.08	1.292	50.14
Learning outcome class B	30	88	98	28	83.53	5.91	1.080	35.01

This research revealed significant differences between the group that used virtual-based learning methods (group A) and the group that used game-based learning methods (group B) in terms of study time and learning outcomes. From Table 6, students in group B spent more and more consistent time on study than students in group A. The mean study time is 49 for group B, 70 hours with a standard deviation of 2.69 while group A on the other hand uses only 42.38 hours with a standard deviation of 3 for students studying at the university level 55. The fact that the study time of students from group B has a higher consistency can be explained by the fact that game elements in learning help to increase students' interest and motivation to study longer. This is true according to the theory of intrinsic motivation on learning, which asserts that there is improvement in the time as well as the frequency of learning, by putting in gamification elements. In this theory on self-determination, motivation derived from within self is viewed as interest and satisfaction that come from performing an activity. Within this context, challenge, recognition, and feedback that come with gamification make students to engage in learning with high levels of enthusiasm. Furthermore, points out the fact that reduced mental load during game-based acquisition may help students' minds to persist longer and not get weary. In some of the related work done, the study reveals the positive results that students in group B have a higher and more stable learning performance compared to students in group A which used a gamification approach to the learning process, and the average score for group B students was higher, 83.53, while in group A it was 77 of them, 83, and there is a statistically significant difference, (t=4.96, p<0.001).

Hamari *et-al* [50]. arrived at similar conclusions in another study where they determined that the use of points, badges, and leaderboards enhanced the students' interest in the course content as well as their performance. Using a game as a knowledge-building tool is more efficient for students because it follows the constructivist learning theory that focuses on the learning process that occurs through the interaction with the subject material and the real-life environment. Theoretically, this research supports the notion that approaches applied in this research effectively transform teaching methodologies into gaming that can effectively lessen the cognitive load, enhance motivation, and foster improved learning. Landers also conducted a study and proved that the incorporation of gamification elements in the learning environment enhances students' engagement and their performances as well. From this perspective, these findings imply that using the gamification elements in the curriculum, especially within the context of the online learning environment, might be useful in encouraging students' engagement and promoting students' achievement [51]–[53]. In conclusion, this thesis offers practical research findings that verify the theoretical claim that the integration of play elements into learning contexts can enhance and sustain the quality and quantity of students' learning time. These results can be used to apply a gamification approach as an integrated part or a replacement of more conventional virtual learning for complex learning environments in which learners are expected to engage actively and gain deep knowledge.

Table 6. Independent samples test learning outcome of group A and B

		Levene's test for equality of variances		t-test for equality of means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean difference	Std. error difference	95% confidence interval of the difference	
									Lower	Upper
Learning outcome	Equal variances assumed	2.347	.131	-3.383	58	.001	-5.70000	1.68483	-9.07256	-2.32744
	Equal variances not assumed			-3.383	56.226	.001	-5.70000	1.68483	-9.07483	-2.32517

5. CONCLUSION

This research indicates that game-based (gamified) learning methods are more effective than other traditional methods of virtual learning in enhancing learning outcomes and strict adherence to time by students. The effectiveness of playing a game-based pedagogy in enhancing learning: students who learn under the gamification approach spend more time studying while realizing better and more stable learning accomplishments. This difference can be explained by the motivational aspects linked to gaming mechanics as well as challenges, rewards, and feedback that do not overload the subject's cognitive abilities. From the above scores, it is statistically possible to propose that learning through gamification leads to improved gains. Regarding educational practice, including the delivery of online education, these conclusions hold significant implications. First, it is possible to use the elements of gamification directly in the curriculum to enhance students' motivation and their active participation in the type of learning that implies deep understanding. Thus, through gamification, the students are willing to spend more time studying and with quality concentration at which directly enhances the quality of the learning outcomes. Second, in line with the above arguments, the findings of this study offer empirical evidence in support of the reduction of cognitive load using gamification. In time-demanding and highly concentrated learning environments, gamification may lead to extended student engagement and, therefore, enhance the learning process outcomes. Points, badges, and leaderboards can be implemented as gamification aspects for usage-oriented learning concepts by educators and curriculum developers mainly for contents, which are boring or which cause difficulties. Furthermore, these results lay the groundwork for subsequent studies to analyze more thoroughly the potential and application of gamification in different learning settings and about various types of learners. Therefore, gamification cannot simply be fully considered a mere trend but rather a teaching strategy that may help increase the overall learning experience.

This research offers valuable contributions to the literature on the use of gamification in learning with the following limitations that need to be considered for future improvement. Another weakness is that the study entails only one course, introduction to coding, which means that the findings may not be generalized to other sciences. Also, the short period of the study may limit the ability of the researcher to gauge the full effects of gamification on learning outcomes or ascertain whether learning would continue to improve beyond the periods under study. This research also fails to delve deeper into analyzing the differences in motivation among students, or how gamification can cause variance, depending on the students' personalities. Furthermore, there is no clear indication of which aspects of the gamification technique are most effective like the points, badges, and leader boards so more research should be conducted to discover the best gamification components. It fails to consider external factors that may also affect the process of gamification including home learning environment and social support. Addressing these weaknesses will help to further elaborate on the theory of gamification and enhance the utilization of gamification in other contexts of learning.

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