# Gamified Learning Theory: The Moderating role of learners' learning tendencies

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## Abstract

*The Gamified Learning Theory implies that gamification does not affect learning directly but stimulates a learning-related behavior in a mediating or moderating process. A learner-related behavior can, to some extent, be predicted based on the way learners tend to perceive, understand and utilize information. These different ways of learning are known as learning tendencies. This study investigates the moderator role of learning tendencies on gamification success concerning learners' academic participation, engagement, and experience. For this, Felder-Silverman Learning Style Model is used for the identification of learners' tendencies. In our study, 69 Computer Science students were randomly assigned to one control and two treatment groups. Students in the treatment groups were assigned two different gamified courses, while the control group attended a non-gamified course. This allowed us to analyze the individual effect of each gamification design and compare and see which gamification design was more appropriate for a learner with particular tendencies. Our results indicate that gamification design positively contributes to academic participation, affects learners' engagement in gamified environments, and that students' learning tendencies moderated students' engagement.*

***Keywords**: Gamification, Gamified Learning Theory, Learning Tendencies, Personalized Gamification, Engagement, Gamified Experience*

## 1 Introduction

The Gamified Learning Theory (GLT) defines gamification as a process of using game attribute categories outside the context of a game to affect learning-related behaviors or attitudes [1]. Game attribute categories are defined by [2] to describe the mental models of serious games. Each category presents a set of game elements that can be implemented in non-gamified environments to trigger specific game-like mental states. Learner-related behavior, just as any behavior, can influence learning. The GLT implies that gamification does not affect learning directly but is instead used to stimulate learning-related behavior in a *mediating* or *moderating* process (see Fig 1.). In the mediating process, "gamification affects learning when an instructional designer intends to encourage a behavior or attitude that will itself improve learning." The learning-related behavior mediates the relationship between game elements and learning. To illustrate, Landers gives an example in which game element storytelling is used to increase students' time with course material. Moreover, since time spent in a course directly affects learning, the more time they spent, the learning will be greater [1]. In the moderating process, designers use gamification to improve the existing instructions, which should encourage a learning-related behavior that leads to better learning outcomes. For example, a gamification designer may implement game elements to encourage students to do more assignments (i.e., increase engagement). However, if the assignments themselves are not effective, the students will not be engaged. In short, Landers implies that, before applying gamification, designers must ensure sound and quality instructional content [3]. Namely, the targeted behavior or attitude (e.g. doing more assignments) must itself influence learning (otherwise, students may end up engaging in learning-irrelevant activities). Gamification can then affect learning-related behavior which moderates the relationship between instructional quality and learning. In this context, gamified learning theory identifies several possible moderators, such as personal, situational, or context moderators [1], [4].

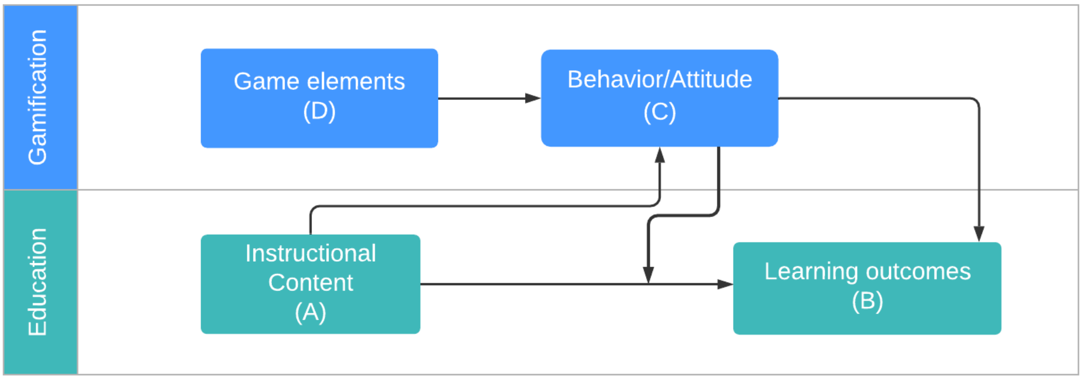


**Figure 1.** *The mediating processes are set from D → C → B and A → C → B. The influence of C on A → B is a moderating process (adopted from [1]).*

Person-level moderators are "psychological constructs or proxies for those constructs that affect how well gamification interventions work across different people" [4]. In education, learners' learning tendencies are regarded as moderators of the relationship between instructional design and learning outcomes. Learning tendencies define "common patterns of student preferences for different approaches to instruction, with certain attributes—behaviors, attitudes, strengths, and weaknesses - being associated with each preference" [5]. Learners' learning tendencies are often used as personalization criteria for creating personalized environments. They have often been applied in educational research, and nowadays, they can also be found in research on personalized gamification. Personalized gamification is designed to "promote a better gameful experience by improving the moderating effect of the psychological characteristics of the user, which is achieved by designing the system in a way that it can be tailored to different users" [6].

In this manner, this work aims to assist future research on personalized gamification by empirically evaluating the moderating effect of learning tendencies on students' academic participation, engagement, and gameful experience in a learning environment (e.g., online course). In addition, this paper seeks to reopen the discussion of learning tendencies and their role in educational gamification, making it a pioneer in investigating learning tendencies as personal moderators of gamification. For that, we designed an experimental study with 69 Computer Science (CS) students who were randomly assigned to one control and two treatment groups. The first treatment group was assigned to the course gamified using the Trading game element and the second with the usage of Points, Badges, and Leaderboards (PBL triad). The control group did not include any gamification features. Our results showed that gamification design positively contributes to academic participation, affects learners' engagement in gamified environments, and that the sensing learning tendency moderated students' engagement. The study also revealed that, in comparison to the Trading items, the PBL triad was statistically more effective regarding students' online engagement and experience in the course.

To present our research, we have organized the remaining of this paper as follows: Section 2 introduces the principles of learning tendencies (defines by the Felder-Silverman Learning Style Model (FSLSM)) and the GLT. The third section presents our research questions and hypotheses. Related work concerning the investigation of moderations in gamification is presented in Section 4. Then the experimental procedure is described, followed by the results in Section 6 and discussion and conclusions in Sections 7, 8, 9 and 10.

## 2 Background

According to Felder and Silverman [7], the inventors of the FSLSM, learning tendencies assert that individuals have preferences along four bipolar dimensions of learning. These dimensions are described as a 'double-pan scale' where 'pans' present the two opposite poles (see Fig 2). Which pan will weigh depends on the strength of the student's tendency toward a particular dimension's side. The stronger the tendency toward one side of the scale, the greater the chance that the student will resort to the 'more likely' behavior for that side of the dimension [8].

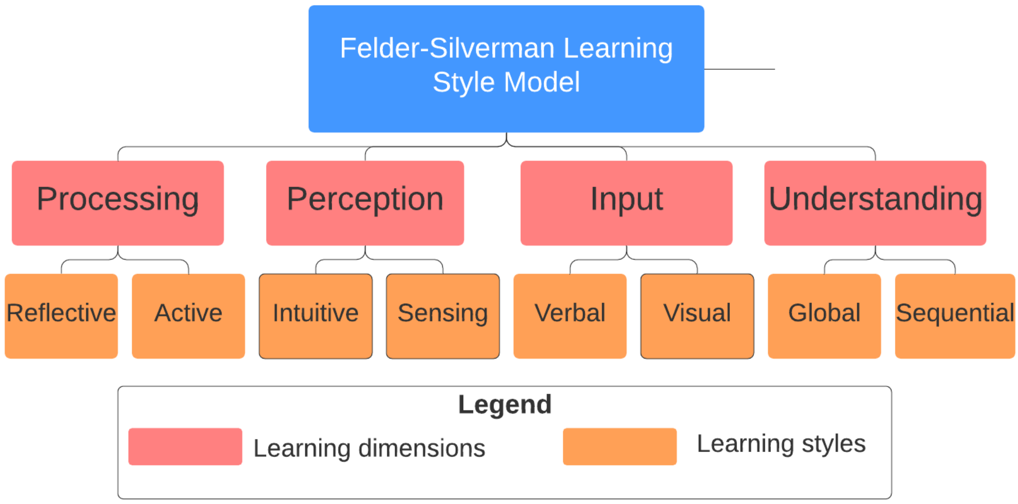


**Figure 2.** *The four dimensions of learning, and the corresponding learning styles/tendencies, derived from the Felder-Silverman Learning Style Model (FSLSM)*

Learning styles have been present in research since 1980. Their principles are based on the idea that students learn in different ways and that successful learning requires that both students and professors become familiar with learning styles to adapt the learning environment to the learning methods that the student prefers. Adapting instructional design to student learning styles is known as the "matching hypothesis," i.e., matching learning style with an instructional medium positively impacts individuals' performance and helps them attain their learning goals. This hypothesis was the base for many works on the personalization of education based on students' learning styles.

In the mid-2000s, two critical studies on the application of learning tendencies were published [9], [10], concluding that there was no adequate evidence base to justify the matching hypothesis and that beliefs in learning styles were 'a consequence of mainstream trends'. Namely, they claim that knowledge of different ways of learning and different learner types is common knowledge for every educational scientist, but that in theories of learning styles, it is misinterpreted and (intentionally) misused for commercial purposes. This view is later joined by studies such as [10]–[13], who add that learning styles theories can also be harmful. For example, a student characterized as 'verbal' by the scientific community may feel demotivated or insecure to realize himself in visual subjects, such as art or design. Likewise, unconditionally relying on learning styles creates an atmosphere in which instructors are expected to provide each student with a 'perfectly adapted learning environment,' which is unrealistic and impossible.

In the light of the ongoing critical discussions about learning tendencies and their miss-interpretation, we summarize below what this work entails (and what does it not entail) under the learning tendency term and how learning tendencies shape the educational design in this work:

- The four bipolar dimensions defined in the FSLSM are seen as a spectrum, not a category since students can have strong, moderate, or mild preferences. The preference defines the more likely behavior of that type of learner. In this context, the keyword is 'likely.' Namely, tendencies do not describe infallible predictors of a student's strengths, weaknesses, success, or grades. Instead, they suggest how students are likely to behave. For example, if students are confronted with various learning materials and situations, those with active tendencies will behave in an 'active manner' more often than in a reflective. The stronger the tendency, the more often they will resort to their 'type of behavior.' By knowing their students' tendencies, instructors can create a balanced environment in which all students can find something meaningful for themselves.
- In a balanced environment, students are encouraged to learn in a way that matches their learning tendencies simultaneously, so they are not too uncomfortable to learn effectively, but also in a way that is at odds with their natural way, so they are forced to advance in the direction they might be inclined to avoid [14]. In other words, instructional design should not unconditionally match learners' learning styles. Instead, it should ensure a diverse environment in which students can fulfill their potential. Hence, the quality of the instructional design is responsible for learners' learning success, not their tendencies. This is in line with the GLT proposition that effective instructional content is crucial to gamification success. That is, gamification cannot be used to replace instruction, but instead, it is used to improve it [1]. Gamification designers should use implications derived from learning tendencies to inform on instructional improvements that could be achieved with gamification.

Based on the implication from the GLT and learning tendencies, we conclude that these theories complement each other and frame a theoretical framework for designing the personalized, gamified intervention. To elaborate:

- Both theories hold that sound instructional design is key to successful learning and that personalization concerning learning tendencies, i.e., gamification, can only enrich the existing environment, by no means can compensate for possible shortcomings of the course.
- Knowledge of the learners' learning tendencies should assist the creation of a balanced environment in which students cope with things they would likely skip or ignore but which are essential for mastering a particular subject. Similarly, gamified learning theory emphasizes the identification of learning-relevant activities to avoid goal-irrelevant engagement of students.
- From the learning tendency's perspective, the relationship between instructional design and learning success depends on learners' learning tendencies, and learning tendencies define learners' likely behavior. In gamified learning theory, the relationship between gamified instructional design and learning success is moderated by learning-related behavior. As so, this work sees learners' learning tendencies as one of the moderators of the relationship between instructional design and learning outcomes in a given course.

To empirically evaluate the described theoretical implications, this work presents an experimental study examining a set of research hypotheses in three research areas. Those are presented in the next section.

## 3 Research areas and hypotheses

This study investigates three research areas (RA): 1) gamification contribution to learning outcomes; 2) the moderating effect of learning tendencies on gamification contribution to learning outcomes; and 3) differences in gamification interventions effects on targeted learning outcomes within distinct learning tendencies. The targeted learning outcomes are students' engagement, academic participation, and gameful experience. Students' engagement is composed of behavioral, cognitive, and emotional engagement and defines time, energy, effort, and feelings students invest in their learning [15]. Academic participation refers to students' interactions and involvement in online learning activities and is a part of students' behavioral online engagement [16]. Gameful experience is a psychological state in which one perceives presented goals as non-trivial and achievable, is motivated to pursue those goals, and believes that actions are volitional [17].

In RA1, we investigate whether gamification improves learning outcomes in comparison to traditional learning. For this, we compare the academic participation and engagement of students who have the same learning tendencies but are attending different courses (gamified and non-gamified). Here, the three hypotheses are derived:

- **H1**: Our gamification designs contribute to the academic participation of students' which learning tendencies are *not* in line with their more likely behavior in the course,
- **H2:** Our gamification designs *do not* contribute to the academic participation of students' which learning tendencies are in line with their more likely behavior in the course, and
- **H3:** Our gamification designs contribute to students' engagement.

In RA2 and RA3, we focus only on the treatment groups. In this manner, RA2 explores two hypotheses: first, we investigate potential differences in targeted outcomes among students with opposite learning tendencies inside each gamified group to see if and how they moderated the effect of gamification design.

- **H4**: Learning tendencies moderate gamification effect on engagement, and
- **H5**: Learning tendencies moderate gamification effect on the gameful experience.

Finally, RA3 explores how the two gamification approaches influence the engagement and gameful experience of students with a particular learning tendency and whether influential differences exist:

- **H6:** Our gamification designs contribute differently to academic participation, and
- **H7:** Our gamification designs contribute differently to students' engagement and gamification experience.

The conceptual model of our RAs and the hypotheses are given in Figure 3.

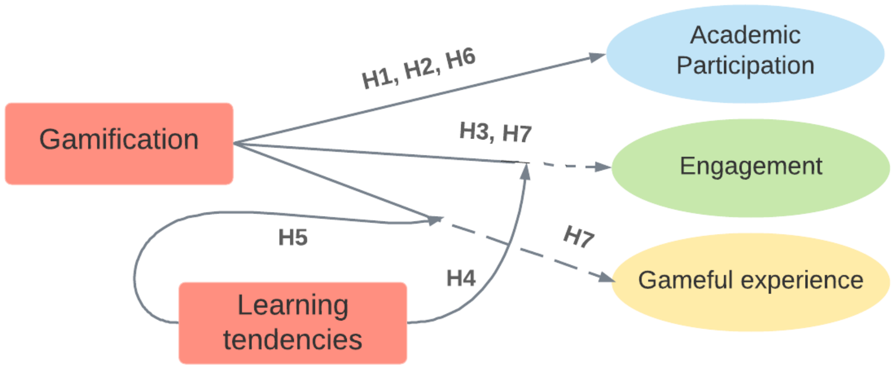


**Figure 3.** *The conceptual model of research areas and hypotheses*

## 4 Related Work

Related research work and publications showed that attitudes towards game-based learning, age, and gender moderate the effect of gamification application on its intended outcomes. For example, in [18], positive attitudes towards learning contributed to higher learning outcomes and positive reactions to training. Vice versa, a negative attitude was correlated with lower training outcomes. In [19], researchers showed that age could influence gamification success, as older adults found gamified environments harder to use. Gender also affects gamification design, as males are motivated by achievement, and females are motivated by collaborative game elements [20].

Regarding the moderating effect of learning tendencies, we found several papers incorporating learning tendencies in personalized gamification design [21]–[24]. However, only one study explored their moderating effect. In [24], the authors showed that tendencies towards processing and understanding dimensions moderated the relationship between gamification design and perception of the intervention. Namely, the authors used achievements, avatars, badges, quests, and teams to boost users' perception, participation, and overall performance in an online course that teaches students to predict tax rates. As reported, students with active processing tendencies had a more positive perception than reflective. Students with a global understanding tendency expressed a more positive attitude than sequential learners, and global learning tendencies positively affected the performance in the gamified course. However, we note the two drawbacks of this study. First, due to the lack of a control group, it is impossible to determine whether gamification has affected performance enhancement or whether the differences occurred precisely because of game elements. Second, as the authors used more than one game element, it is unclear which particular element contributed to positive outcomes. In fact, in most studies on gamification, researchers are using the combination of two or more game elements, which makes it impossible to understand the role of the individual game element in a given context [25]. If gamification with multiple game elements affected learning, researchers can only claim that such a precise combination of elements can lead to change in learning, but results like these contribute little to the community as their construct and external validity are questionable.

In the absence of satisfactory evidence on the links between learning tendencies and game elements, we conducted an exploratory study to investigate gamification contribution to students' engagement by taking into account their learning tendencies [26], [27]. For that, we developed an online JavaScript (JS) course for Bachelor students in Computer Science (CS), who registered for the elective "Web Technologies" module taught every winter semester at the RWTH Aachen University. The JavaScript course was intended to provide students with the necessary knowledge to seamlessly follow the Web Technologies course. The Web Technologies course covers basic web technologies and languages such as HTML/CSS, JavaScript, PHP, JSON, etc. In the last few years, lecturers in this course have noticed that students are struggling with mastering JavaScript modules and that many have complained that this part is too advanced. In this regard, we came up with the idea to create an Introduction to JavaScript course to allow students to get acquainted in detail with this programming language. Participation in the JavaScript course was voluntary, and anyone who felt that he did not need additional classes could bypass this course. However, to encourage students to enroll and complete the Introduction to JavaScript course, students had a chance to earn five bonus points as entry points for Web Technologies.

The exploratory experiment included 124 students randomly assigned to the control and experimental group. The experimental group presented a gamified version of the course, in which gamification was designed with the PBL triad. This study revealed that our gamification design increased students' engagement, students' engagement differed depending on one's learning tendency, and gamification did not affect all students in the same way. Further, the qualitative analysis showed students' had positive attitudes towards gamification, which encourages further investigation in this direction. However, due to the nature of the exploratory study, it was not possible to conclude the relationship between game elements and learning tendencies. In this manner, the present study aims to exceed previous limitations by creating one control and two treatment groups in which each treatment is designed with one game element. The presence of two treatment groups provides the basis to observe: (i) whether learning tendencies moderate gamification influence students' academic participation, engagement, and experience, and (ii) which gamification design is more appropriate for which learning tendency.

# 5 Method

Same as in our previous work [26, 27], the online JS course was used for the study setup, but with a new cohort of students. The JS course was organized as a one-month course (October to November 2019), realized within the Moodle Learning Management System (LMS) [28]. The course covered six topics, ranging from basic to advanced concepts of JS. Although the material complexity grew linearly, all the topics were open and accessible from the very beginning. Each topic consisted of various learning materials such as pdf files (e.g., books and lecture notes), videos (e.g., lecture recordings and practical examples), downloadable code examples, and supplementary materials (e.g., links to external sources and examples).

Further, multiple assessment activities, like quizzes and assignments, were provided. There were two types of assignments – exercises and coding challenges. For exercises, students were invited to submit their solutions to receive feedback from the instructor, even though the instructor's solutions were available on the exercise page. As for the coding challenges, solutions were hidden, and students could access them only after submitting their own. Regarding quizzes, the course offered self-assessment and grading quizzes. Namely, five quizzes were part of the bonus points system (1 point for each quiz), while six quizzes were not graded. In total, the online JS course had five lecture notes, 622 minutes of recording lectured arranged in 45 videos, six coding challenges, five bonus-point quizzes, ten self-assessment quizzes, 16 exercises, and seven supplementary resources. In addition to these six learning units, an introductory (with a forum, information on the course organization, and the outlines) and a concluding unit (for the evaluation) were available. The instructor actively interacted in the course only when an announcement had to be made, or students (virtually) asked for assignment feedback or had questions.

### 5.1 Targeting the Behavior for Gamification Intervention

CS education, by its nature, combines theoretical and practical concepts. This indicates that students should be able to solve problems in a well-known way, using algorithms and facts, but also use principles and theories to discover new relationships, create creativity and find innovative solutions. According to FSLSM, students who prefer theory over practice enjoy finding new solutions, like challenges and innovation, dislike using repetitive methods, have intuitive learning tendencies (tendencies to express theoretical knowledge). Oppositely, students who tend to solve problems by standard methods, using facts and experimentation, enjoy practicing over inventing, dislike complications and theories, are characterized as students with sensing learning styles (tendencies towards expressing practical skills). Studies on learning tendencies showed that every learner could use both perception ways, but most of the time, they use only one of them – which is the sensing way in the case of CS students [29]. Thus, it is important to establish a balance between what learners must learn or work on to master a subject - and what and how they prefer to learn. Due to the majority of CS students having sensing learning tendencies [30], this work aims to encourage sensing students to engage in tasks that they might, because of their sensing nature, avoid. In other words, our gamification intervention aims to boost students' engagement by triggering the 'intuitive behavior' in sensing students.

### 5.2 Selecting Game Elements

The selection of game elements that were used in this study was made using three criteria: (1) gamification purpose (game elements that can support the behavior of students with intuitive tendencies), (2) gamification environment (game elements available in the learning environment) and (3) the results of our previous experience.

We first looked at the GLT to identify which game elements can fit into our intervention purpose (i.e., trigger the intuitive perception dimension). As perception refers to "organization, identification, and interpretation of information to represent and understand the environment" [31], we identified the Assessment game attribute category as a suitable one. Assessment game attribute presents the measurement of achievement (e.g., scoring) within a game and how the player advances toward game goals [32]. Assessment is provided with feedback, scoring/goals progress, levels, and leaderboards. It provides information concerning the player's performance and indicates what goals have yet to be completed [2]. In the next step, we analyzed what game elements are available in the test environment (Moodle LMS) that can be used to support learners' assessment. This narrowed down the selection list to the four game elements: experience points (XPs), levels, and leaderboards [33], badges [34], and Item trading [35]. *Item trading* in its simplest form is "an incentive exchange of some kind of Resources/Items between the player and the game" [36]. In the learning context, students collect items (achievements) and trade those for goods that can help them progress forward by getting involved in the course. Thus, the first selected game element to be used for the first treatment group is Item trading. Our course offered three sets of tradeable items – coins, puzzle pieces, and food ingredients that could be picked up in various course sections (see Fig 4. and Fig 5.).

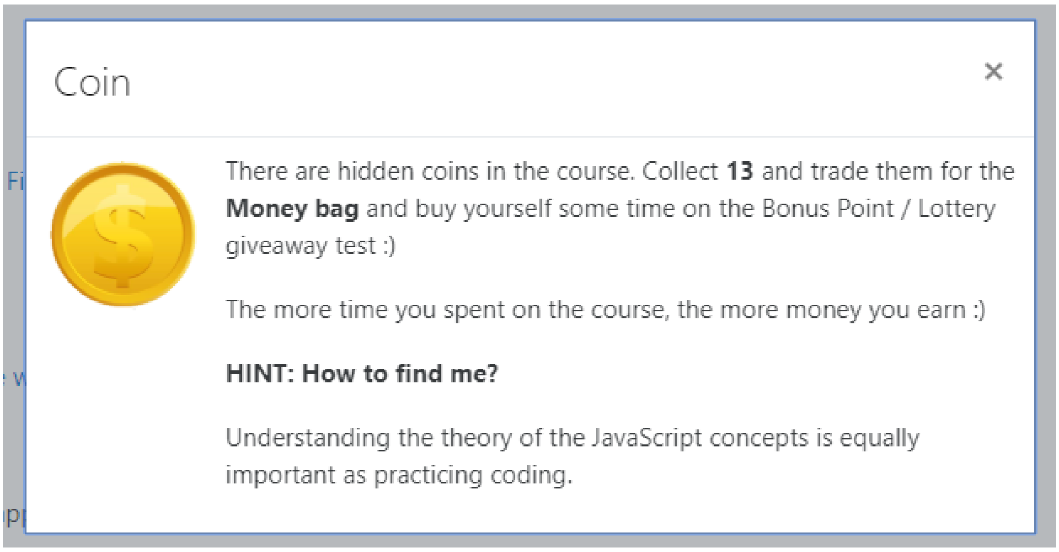


**Figure 4.** *The description of the tradable item*

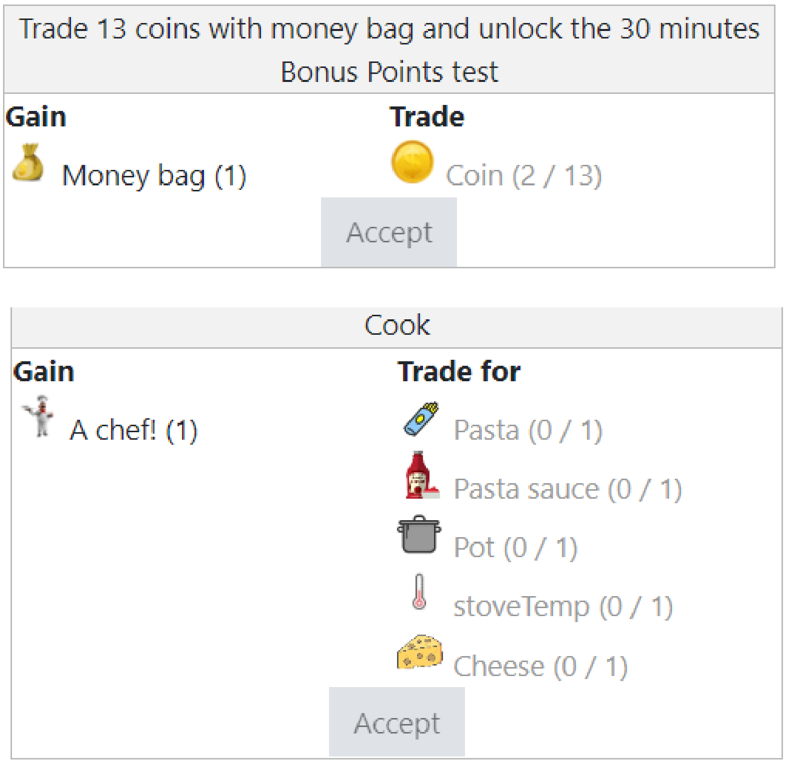


**Figure 5.** *The item trading widgets*

For the second treatment group, we choose the PBL triad. As the findings from our previous work showed [27], applying PBL concerning learners' learning tendencies has its potential, but to be fulfilled, some improvements are needed. The implications derived from the qualitative analysis of our previous work are:

- First, badges should be more competitive by showing who the student is up against. For this, besides the XPs' and levels, a leaderboard included a list of earned badges. Besides, a student should know which learning actions bring how many XPs and what actions have to be taken to earn them.

- Badges should be visually better positioned and reflect on students' knowledge and skills gained while doing the assignment. They should also be more competitive by showing who the student is up against.
- A student should be informed on which learning actions bring how many XPs and what actions must be taken to earn them. The system should also provide clear information on what a new level brings.
- A feedback system is needed that will inform students about any change (i.e., students leveled up).
- All gamification elements should be easily available from the course page and placed in one section.

To fulfill these requirements, we developed Interactive Gamification Analytics Tool (IGAT) [37], a plugin for Moodle LMS that combines badges and levels in a meaningful way, providing both students and teachers valuable insights on gamification usage. The plugin was built upon existing Moodle LMS gamification plugins [33, 34] and placed on the right side of a course page (see Fig. 6 and Fig. 7).

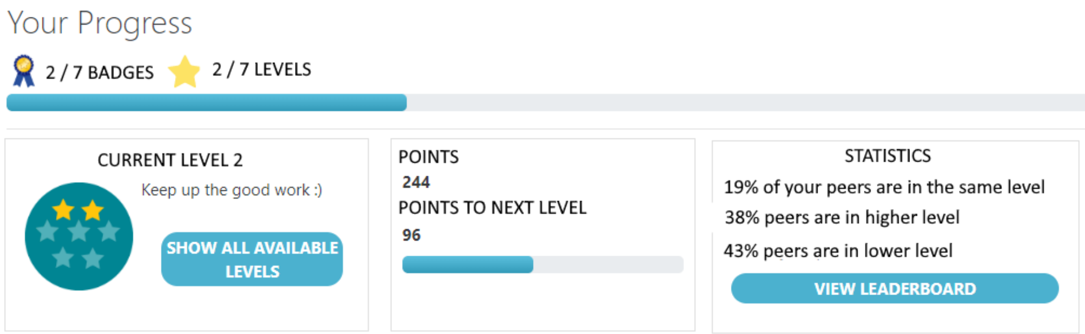


**Figure 6.** *The progress preview*

| Rank | Name | Points | Level | |
|---|---|---|---|---|
| 1 | Student 1 | 1837 | 7 | |
| 2 | Student X | 1659 | 7 | |
| 3 | Student Y | 1645 | 7 | |
| 4 | Student Z | 1627 | 7 | |
| 5 | Student XYZ | 1610 | 7 | |

**Figure 7.** *The leaderboard preview*

## 5.3 *The meaningful gamification intervention*

The meaningful gamification design manages to target curtain behavior, whose change results in the desired gamification outcome [38]. In this study, the meaningful gamification intervention aims to boost students' academic participation, engagement, and gameful experience by triggering the behavior that students with tendencies toward intuitive perception have. Table 1 describes how the gamified interventions were designed regarding the 'intuitive behavior' they intend to encourage.

**Table 1.** *Overview of included game elements and experimental manipulations*

| | |
|---|---|
| ***Aim: Encourage students to try new solutions on their own*** | |
| *T1* | **Collecting puzzle pieces:** Puzzle pieces were hidden inside the coding challenges. A student could pick up a piece (by clicking on the item image) and unlock the instructor's solution when a submission is made. When all six pieces are collected, students trade them with the 'getaway card' to freely skip one of the tests for bonus points. |
| *T2* | **Badges**: Badges were automatically awarded to students when they submit a coding challenge. If all six badges are earned, students get the 'getaway card.' |
| *Control* | Submitting coding challenges was optional, and the solutions were open. Skipping the test was not possible. |
| ***Aim: Encourage students to watch videos with theoretical explanations and concepts.*** | |
| *T1* | **Collecting coins:** Students collected coins by watching a theoretical video. Coins could be traded with ten extra minutes for two Bonus tests of their choice. |
| *T2* | **XPs and levels**: Students collected 45 XPs by watching theoretical videos. When they collect 450 XPs, respectively, 900 XPs, they unlock the 30-minutes tests. |
| *Control* | No awards for watching the videos. No possibility to extend the Bonus Tests time. |
| ***Aim: Encourage students to explore the course, doing additional exercises and quizzes.*** | |
| *T1* | **Collecting food ingredients***:* the ingredient items were hidden inside additional activities like self-assessment quizzes. Once all ingredients are collected student unlocks a new learning section with supplementary materials on advanced JS concepts. |
| *T2* | **Levels and leaderboard:** By doing self-assessment exercises and quizzes, students were given additional XPs. When a certain amount of XPs is being collected, students leveled up. When the ultimate level 7 is reached, additional learning materials are unlocked. Students' current XPs and levels are shown on the leaderboard. |
| *Control* | The additional material section was available from the beginning. |

### *5.4 Data and Feedback Collection.*

To examine the hypotheses mentioned in Section 3, data from four sources were collected. First, to identify learners' learning tendencies, the Index of Learning Style questionnaire [39] was integrated into the course as a Moodle LMS plugin [40]. For the students' engagement, we created a self-reporting instrument combining behavioral engagement scales from the Student Engagement Questionnaire (SEQ) [41], emotional and cognitive engagement scales from the Intrinsic Motivation Inventory (IMI) [42], and cognitive engagement scale from the Motivated Strategies for Learning Questionnaire (MSLQ) [43]. The behavioral engagement was assessed with the Online Active (OA) scale that measures how actively students use online learning systems to enhance their learning, and Online Engagement (OE) scale measures the degree to which students have applied the e-learning system into their academic performance studies. The interest and enjoyment scale from IMI was used to measure students' emotional engagement (EE). Finally, the invested effort in the course (IE) from IMI and effort/regulation (ER) from MSLQ were used for the cognitive engagement. Behavioral engagement scales used a 4-point Likert scale (1 = never to 4= very often), while emotional and cognitive scales use a 7-point Likert Scale (1 = strongly disagree to 7 = strongly agree).

Besides, each event within the LMS was collected from log data. This information was used to measure students' academic participation and provide supplementary information regarding their online engagement. Students' gameful experience was measured with a Gamefulquest [44]. Gamefulquest is a validated instrument used to model and measure the users' gameful experience when using a gamified system. This instrument provides seven scales for assessing gamified experience: playfulness, accomplishment, challenge, competition, guidance, immersion, and social experience. Finally, we acknowledge that participation in the course was free and that each student was individually asked whether he/she allows the data mentioned above to be used in our experiment. Also, students were informed that no personal data had been collected (that students have been identified by a unique ID, which in no way can be linked to their personal data). Table 2 summarizes the data used in this study.

**Table 2.** *Measures and data used in the study*

| | RAs to which the data corresponds | Data set |
|---|---|---|
| **Unique ID** | RA1, RA2, RA3 | unique ID, which represents student' ID in Moodle' User' database table |
| **Learning Tendencies** | RA1, RA2 | ILS test results (e.g. user with ID '42' has '7', '1', '3', '5' scores) |
| **Engagement** | RA1, RA2 | Students engagement survey |
| **Experience** | RA2, RA3 | Gamification engagement survey - Gamefulquest |
| **Academic participation** | RA1, RA2, RA3 | *Time spent in course, Activities (No. of events, course visits), Self-assessment (No. of completed self-assessment quizzes and exercises), Coding challenges (No. of submitted challenges), Learning materials (visits to lecture notes, additional material), Gamified videos (No. of watched videos)* |

# 6 Analysis and Results

The JavaScript course was attended by 85 Bachelor CS students from RWTH Aachen University randomly assigned to one of the three groups. From those, 69 students approved using the data (see Table 3) and thus were included in the study. All extracted data were analyzed by using the IBM SPSS tool [45]. Based on the assessment of the data normality, for measuring differences among groups, parametric (Independent t-test) or nonparametric (Man Whitney U and Kruskal-Wallis) tests were used. Further, a simple regression was used to investigate the moderating effect of learning tendencies [46]. The significance is measured at a level of $\alpha$=5% (p-value<.05).

**Table 3.** *Students' distribution in the experiment*

| | Control Group 20 students | | T1 Group 26 students | | T2 Group 23 students | |
|---|---|---|---|---|---|---|
| | **Intuitive** | **Sensing** | **Intuitive** | **Sensing** | **Intuitive** | **Sensing** |
| | 5 | 15 | 11 | 15 | 9 | 14 |
| **Engagement survey** | 9 students | | 21 students | | 14 students | |
| **Gamefulquest** | NA | | 24 students | | 14 students | |

## 6.1 Descriptive and reliability analysis

We start the inquiry by analyzing descriptive data on students' academic participation and engagement. On average, students from the control group spent 7 hours in the course (M=422.6, SD=270.3), while their peers from the treatment groups spent approximately 11 to 12 hours (M=659.9, SD=365 in T1, and M=739, SD=484.3 in T2). Students spent most of their time during the first four weeks (the period in which bonus points tests were open), which was a trend in all groups. Specifically, 16/20 (80%) from control, 14/26 (53.8%) from the T1, and 16/23 (69.5%) from the T2 group did not access the course after the period for bonus test was over. Regarding the assessment activities, students have completed most of the bonus points test (on average 58% in control, 84% in the T1, and 66% in the T2 group). As far as assessments tasks are concerned, students mostly worked on tests for the bonus points (students on average completed 2.9/5 tests in the control group, 4.2/5 in the

T1 group, and 3.3/5 in the T2 group), followed by the self-assessment quizzes (3.2/10 in control and 5.3/10 in treatment groups) and coding challenges (0.2/6, 1.3/36, 1.6/6). As for the learning materials, in proportion, the most accessed materials were lecture notes, followed by videos and example source codes from video lectures.

Reliability analyses on the behavioral, emotional, and cognitive engagement scales were conducted to ensure the items consistently reflect the construct being measured by each scale. The Cronbach alpha coefficient reflects the average correlation of items within a scale, and acceptable values of internal consistency range from .7 to .8. An examination of the scales for each engagement dimension revealed that 5 of the scales obtained alpha coefficients above the .7 criterion for satisfactory internal consistency [45], while two scales obtained alphas between .5 and .7 (see Table 4). These items were negatively phrased and reversed scored, reflecting a miss-comprehension or misunderstanding of the statements [47].

**Table 4.** *Reliability analyses of the behavioral, emotional, and cognitive engagement scales*

| Dimension | Scale | No. of items | M | Alpha |
|---|---|---|---|---|
| **Behavioral engagement** [a] | Online Active Engagement | 5 | 2.6 | .804 |
| | Online Engagement | 4 | 2.96 | .826 |
| **Emotional engagement** [b] | Interest/Enjoyment | 7 | 4.40 | .831 |
| **Cognitive engagement** [b] | Effort/Importance | 5 | 4.28 | .683 |
| | Effort/Regulation | 4 | 4.26 | .603 |
| | Active learning | 5 | 4.43 | .837 |
| | Academic challenge | 5 | 3.92 | .720 |

Notes: [a] Likert type response scale 1 - 4; [b] Likert type response scale 1 – 7;

As for the reliability of the gamification satisfaction scale, all sub-items within the scales meet the sufficient criteria of Cronbach alpha being >.7. The scales are presented in Table 5.

**Table 5.** Reliability analyses of the gameful experience scale

| Treatment groups | Scale | No. of item | M | Alpha |
|---|---|---|---|---|
| **T1** | Accomplishment | 8 | 4.05 | .960 |
| | Challenge | 8 | 3.11 | .978 |
| | Playfulness | 9 | 3.61 | .973 |
| **T2** | Accomplishment | 8 | 5.45 | .970 |
| | Challenge | 8 | 4.52 | .964 |
| | Playfulness | 4 | 4.79 | .965 |
| | Competition | 9 | 4.90 | .953 |
| | Guided-progress | 8 | 4.69 | .943 |

## 6.2 RA1: Gamification Contribution to Learning Outcomes

In this research area, we seek to investigate whether our gamification design improved academic participation compared to traditional e-learning design. For this, we compare the academic participation of students who have the same learning tendencies but are attending different courses (gamified and non-gamified). As game elements were applied to boost students' academic participation (submit more coding challenges, do more exercises, explore the course, watch videos and thus spend more time in the course), we assume that academic participation and engagement will be higher for students in gamified environments (H1, H3). However, since this kind of participation is common for students who have tendencies towards intuitive learning, we assume that our gamification design will only affect sensing students and not intuitive (H2). Namely, as stated in [48], the "gamification effect can happen if the change of behavior can happen," and here the behavior of intuitive students does not change."

***H1****: Average academic participation of sensing students in the treatment (gamified) is higher than in control (non-gamified) conditions.*

***H2****: There are no significant differences in average academic participation of intuitive students among control and treatment groups.*

***H3****: Average engagement scale scores of intuitive and sensing students are higher in the treatment groups.*

Table 6 presents the results of the Kruskal-Wallis test. The test revealed differences in academic participation of sensing students between the three groups. Namely, in the T1 group, sensing students (n=15) had significantly more actions, watched more gamified videos, and accessed more learning materials than their peers from the control group (n=15). Similarly, in the T2 group sensing students (n=14) were significantly more active than the peers from the control group. From this, we conclude that gamified interventions directly impacted students' academic participation in the course, and therefore, *H1 is confirmed*.

Results of the Kruskal-Wallis test (see Table 6) did not reveal significant differences between intuitive students' (n=25) across the three groups; thus, *H2 failed to be rejected*.

Regarding H3, the results of the Kruskal-Wallis test (see Table 7) show no significant differences in the effects of our gamification designs on students' engagement. Thus, *H3 is not confirmed*.

**Table 6.** *Comparison of academic participation between control and treatment groups*

| | df | H | p | Control$^{MR}$ | T1$^{MR}$ | T2$^{MR}$ | Control - T1 | Control - T2 | T1 - T2 |
|---|---|---|---|---|---|---|---|---|---|
| **Time** | 2 | 3.69 | .15 | 17.33 | 24.93 | 25.43 | | | |
| **Actions** | 2 | 10.67 | .005** | 14.30 | 29.47 | 23.82 | .001** | .04* | .23 |
| **CC**[a] | 2 | 9.25 | .01** | 5.87 | 23.17 | 28.89 | .08 | .002** | .18 |
| **SA**[b] | 2 | 6.90 | .11 | 17.73 | 25.70 | 24.18 | | | |
| **LM**[c] | 2 | 10.10 | .006** | 14.20 | 28.57 | 24.89 | .002** | .03* | .44 |
| **GV**[d] | 2 | 13.76 | .001** | 13.37 | 30.67 | 23.54 | .033 | .02* | .13 |

Note: * = p<.05, ** = p<.01, [a] Coding Challenge, [b] Self-assessments, [c] Learning materials, [d] Gamified videos, $^{MR}$ Mean rank

**Table 7.** *Engagement comparisons among groups, Kruskal-Wallis test's results*

| | Intuitive students | | | | | | Sensing students | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **df** | **H** | **p** | **Control** [a] | **T1**[b] | **T2**[c] | **df** | **H** | **p** | **Control** [d] | **T1**[e] | **T2**[f] |
| **OA**[i] | 2 | 1.69 | .43 | 12.0 | 7.94 | 10.58 | 2 | 3.67 | .16 | 12.83 | 13.27 | 19.88 |
| **OE**[j] | 2 | 1.73 | .42 | 9.67 | 8.0 | 11.67 | 2 | .563 | .76 | 13.5 | 14.67 | 16.75 |
| **EE**[k] | 2 | .96 | .63 | 11.50 | 9.83 | 8 | 2 | 3.0 | .22 | 14 | 13.07 | 19.38 |
| **ER**[l] | 2 | 1.66 | .43 | 12.67 | 8.17 | 9.92 | 2 | 2.84 | .24 | 10.08 | 15.6 | 17.56 |
| **EI**[m] | 2 | 1.33 | .51 | 11.67 | 8.11 | 10.5 | 2 | 3.1 | .21 | 9.92 | 17.3 | 14.81 |

Note, [a.] n=3, [b.]n=7, [c.] n=6, [d.] n=6, [e] n=14, [f] n=8, [i] Online Active, [j] Online Engagement, [k] Emotional Engagement, [l] Effort Regulation, [m] Effort Invested.

## *6.3 RA2: The Moderating Effect of Learning Tendencies on Students' Engagement and Gameful Experience*

In this research area, we focus only on the treatment groups. First, we investigate potential differences among students with opposite learning tendencies in each gamified group to see if and how a particular game element affects students' engagement (H4) and gameful experience (H5) with specific learning tendencies. With this, we understand if and how students' learning tendencies moderate the targeted gamification outcomes.

***H4****: Average scores on engagement scales differ between intuitive and sensing students in the treatment groups.*

***H5***: *Average scores on gameful experience scales differ between intuitive and sensing students in the treatment groups.*

The results of the Independent t-test revealed that the EI of sensing students (n=14) in the T1 group was statistically higher than the EI of intuitive students in the T1 group (n=7) (see Table 8). Further analysis with simple regression established a tendency towards sensing perception could significantly predict EI, $F(1, 21) = 4.72$, $p < .05$, and that tendency accounted for 18.4% of the explained variability in EI. The test also showed that sensing students in the T2 group (n=7) had higher OAE and EE than intuitive (n=7). The analysis showed the sensing tendency could significantly predict OA, $F(1, 12) = 11.21$, $p < .005$, and accounted for 48.3% of the explained variability. Further, the tendency could significantly predict EE, $F(1, 12) = 6.55$, $p < .005$ as it accounted for 35.3% of the explained variability. From this, *we conclude that H4 is partially confirmed.*

Regarding H5, a t-test revealed no significant differences between sensing and intuitive students regarding their gamified experience (Table 8). Thus, H5 *is not confirmed.*

**Table 8.** *Comparison engagement and gameful experience between intuitive and sensing students*

| | T1 group | | | | T2 group | | | |
|---|---|---|---|---|---|---|---|---|
| | **t(21)** | **p** | **Intuitive** | **Sensing** | **t(12)** | **p** | **Intuitive** | **Sensing** |
| **OA**[a] | -1.79 | .08 | 2.13±.68 | 2.70±.65 | -2.52 | .02* | 2.46±.54 | 3.25±.59 |
| **OE** [b] | -1.99 | .05 | 2.41±1.07 | 3.1±.61 | -.06 | .94 | 3.12±.70 | 3.15±.99 |
| **EE** [c] | -.74 | .43 | 4.0±1.74 | 4.4±.88 | -2.54 | .02* | 3.64±1.23 | 5.14±.97 |
| **EI** [d] | -2.17 | .04* | 3.86±1.2 | 4.74±.75 | -.61 | .55 | 4.5±1.65 | 4.9±.80 |
| **ER** [e] | -1.28 | .21 | 3.86±118 | 4.5±.94 | -.54 | .59 | 4.13±.90 | 4.55±1.68 |
| **AC** [f] | .108 | .91 | 4.11± .71 | 4.02±1.97 | -1.63 | .12 | 4.72±1.9 | 6.0±.99 |
| **CH** [g] | .257 | .79 | 3.22±1.58 | 3.05±1.59 | -1.85 | .08 | 3.64±1.62 | 5.18±1.40 |
| **PL**[h] | .591 | .56 | 3.87±1.32 | 3.45±1.88 | -1.37 | .19 | 4.14±1.64 | 5.27±1.41 |

*Note,* [a] Online Active, [b] Online Engagement, [c] Emotional Engagement, [d] Effort Invested, [e] Effort Regulation, [f] Accomplishment, [g] Challenge, [h] Playfulness.

## 6.4 RA3: The Effect of Different Gamification Intervention on Students' Engagement and Gameful Experience

In this RA, we explore how different gamification interventions influence the targeted outcomes of students with a particular learning tendency.

***H6***: Average *academic participation of sensing and intuitive students is different across the two treatment groups.*

***H7***: Average *scores on* e*ngagement and gamified experience scales between students across the treatment groups are different*.

**Table 9.** *Comparison of engagement and gameful experience of students with the same learning tendency*

| | Intuitive | | | | Sensing | | | |
|---|---|---|---|---|---|---|---|---|
| | **t(14)** | **p** | **T1**[a] | **T2**[b] | **t(19)** | **p** | **T1**[c] | **T2**[d] |
| **OA**[a] | 1.04 | .31 | 2.13 ±.68 | 2.45±.49 | -2.39 | .03* | 2.7 ± .64 | 3.37±.52 |
| **OE** [b] | 1.57 | .13 | 2.41 ± .07 | 3.14 ±.64 | -.09 | .92 | 3.1 ± .63 | 3.14±1.07 |
| **EE** [c] | .31 | .75 | 4.0 ± 1.74 | 3.75 ± 16 | -1.86 | .07 | 4.43± .90 | 5.24 ± 1 |
| **EI** [d] | -.62 | .54 | 4.19 ± 1.1 | 4.06 ± 53 | -.63 | .53 | 4.62± .75 | 4.85 ± 85 |
| **ER** [e] | -.35 | .72 | 3.87±1.18 | 4.06 ±.85 | .11 | .91 | 4.74± .75 | 4.68±1.78 |
| **AC** [f] | -.65 | .52 | 4.26±1.71 | 4.72±1.88 | -2.63 | .004** | 4.02±1.97 | 6.0 ± .99 |
| **CH** [g] | -.50 | .62 | 3.22±1.58 | 3.64±1.62 | -3.18 | .004** | 3.05±1.59 | 5.18± 1.4 |
| **PL**[h] | -.35 | .72 | 3.92±1.32 | 4.14±1.64 | -2.38 | .02* | 3.45±1.88 | 5.27±1.41 |

Note: *=p<.05, ** = p<.01, [a] n=9, [b] n=7, [c] n=7, [d] n=14, [a] Online Active, [b] Online Engagement, [c] Emotional Engagement, [d] Effort Invested, [e] Effort Regulation, [f] Accomplishment, [g] Challenge, [h] Playfulness.

The Kruskal-Wallis (see Table 6) test showed no differences in academic participation; thus, the *H6 is not confirmed*. Regarding H7, Table 9 showed that the OA of sensing students in T2 was statistically higher than that of the T1 group. Further, sensing students in the T2 group had a higher gameful experience. However, there were no differences between intuitive students among T1 and T2; thus, *H7 is partially confirmed*.

## 7 Discussion

This study makes five primary contributions to the growing research on GLT and gamification. First, we introduced a theoretical rationale to the usage of learning tendencies to identify a learning-related behavior. Specifically, tendencies for the *perception* learning dimension were discussed concerning how they shape students strengthens, i.e., weaknesses in solving practical or theoretical tasks. From this, a learners' likely behavior in the course is identified and used as a framework for gamification design. To the best of our knowledge, considering learners' learning tendencies as personal moderators of gamification success has not been done before, making this study a pioneer in this research field.

Second, this study indicates the causal gamification effect explained in the GLT, i.e., that gamification can produce change only if the targeted behavior can itself be changed. Namely, game elements were incorporated in activities sensing students tend to avoid, that is, in activities, intuitive students by their nature tend to do. Hence, this study assumed that the change would happen only in the behavior of sensing students. This assumption was indicated as the academic participation of sensing students increased in both treatment groups (H1) while the academic participation of intuitive students was more or less the same among groups (H2). With this, our study empirically confirmed that gamification contributes to positive but casual behavioral change, i.e., gamification can produce change only if the targeted behavior can itself change.

Third, this study supports the moderating GLT theory: 1) a sensing tendency significantly affected students' effort and interest in the T1 group. This indicates that the implementation of Item Trading game element in learning activities that (sensing) students tend to avoid can increase their cognitive engagement; 2) sensing tendency increased the usage frequency of learning materials (Online Active engagement) and had a positive effect on students' emotional engagement in the T2 group. Specifically, sensing students expressed higher interest and enjoyment while interacting with PBL, in comparison to intuitive. To summarize, having a sensing tendency statistically improved students' behavioral and emotional engagement in T2 and cognitive engagement in the T1 group.

Fourth, by showing a significant difference in the effect of two gamified interventions on students' engagement and experience, this study highlights the importance of exploring and comparing multiple game elements to find the most effective gamification design for a particular user group [8]. Namely, as H7 results showed, sensing students expressed higher levels of accomplishment, challenge, and playful experience with the PBL triad design compared to the Item Trading design. Also, their Online Active engagement was statistically higher. Further, despite the ongoing criticism of using the PBL in gamification intervention, this study showed that the PBL triad could positively influence users' engagement and experience if appropriately designed.

Finally, to the best of our knowledge, this study is the first that compares two learner-centered gamification interventions and one of the few that examined the effect of a single game element (Item Trading). Hence, the provided results contribute to further investigation in this direction.

# 8 Limitations

We identified four primary limitations of this study. First, as the results regarding H3 showed, the treatment conditions in comparison to our control did not contribute to students' engagement. We see two potential reasons for this. First, the subjective nature of the engagement survey may show an inaccurate engagement picture. Secondly, gamification was designed to increase academic participation directly and indirectly engagement. As the increase in engagement did not happen, the impact of academic participation on engagement needs further examination. Namely, in addition to the moderators, there are also mediators in gamification [1]. A mediator occurs when gamification does not directly affect the outcome, but the effect is done through the third variable (e.g., time spent in course positively affects behavioral engagement) [8]. Thus, the regression of academic participation data on engagement could better understand how learner-related behavior affects engagement.

Second, results for H7 showed differences in both treatment groups regarding students' engagement, but there were no differences in students' behavior (academic participation) (H6). Since PBL and Item trading game elements were implemented in the same learning activities to tackle the same learning behavior, we could conclude that if gamification design is meaningful (elements are designed to tackle the behavioral change), which exact game elements will be applied in the design may not play the role on their effect on behavioral change. However, to confirm this assumption, multiple experiments with combinations of the various game element are needed.

Third, to avoid the possibility of an inaccurate conclusion, we used a low value for the significant measure ($p<.05$). However, the results would benefit from a higher number of participants. Namely, to reduce the conclusion validity threats, the literature recommends a minimum of at least 50 cases per group; thus, repeating an experiment with more participants would be beneficial [45].

Finally, because this study is a pioneer in investigating learning tendencies as personal moderators of gamification, it is not possible to state that the outcomes of this study are generalizable. However, they do provide strong support for the assumption regarding the moderating effect of learning tendencies on gamification success.

# 9 Conclusion and implications for the future work

This paper describes the research on the moderator role of learners' learning tendencies in gamified interventions. The research confirmed the implication of the GLT, that is, gamification affects targeted outcomes through a moderating process. The results, although somewhat limited, undoubtedly indicate that learning tendencies have a role to play in gamified learning environments and should not be neglected. At least not until proven otherwise. As of, we strongly encourage all researchers interested in both education and gamification to consider learners' learning tendencies in their (gamified) instructional design. In this manner, our paper concludes with both recommendations for our future empirical work and implications for the theoretical framework.

## 9.1 Recommendations

New empirical investigations should follow this work to overcome the aforementioned limitations and reduce the possibility of validity errors. First, the PBL and the Item Trading game element should again be applied, but in a way to encourage intuitive students to behave 'more like' sensing students. If such an environment succeeds in enhancing academic participation and the engagement of intuitive students, it will once again confirm that gamification can succeed only if it targets the behavior that can genuinely change. On the other hand, if no changes occur, this will mean that the PBL triad and the Item trading game element may not affect intuitive students. Results like these would then require further investigation for other game elements that can lead to improvements. Besides, results on the moderating effect of learning tendencies in a gamified environment adjusted to fit students' needs will provide broader knowledge on how learning tendencies influence gamification outcomes concerning different gamification designs and to both 'panes' of perception dimension.

## 9.2 Implications

We suggest that all parties interested in including learners' learning tendencies in their study strive for the following tasks. First, we should identify different learner types and understand their natural behavior, knowing that many students have, for example, a sequential learning tendency can and should motivate gamification designers to create gamified interventions in which students learn in a linear process. For instance, sequential learners will probably welcome an intervention in which students progress through levels and unlock new learning units. On the other side, these fun and game-like elements may boost interest among global students as well, who by their nature do not follow a sequential, step-by-step learning path.

Next, we should create balanced gamified learning environments – learners' learning tendencies are not responsible for learners learning success. However, the quality of the instructional design is. To create a balanced gamified environment, gamified interventions must be designed in a manner that addresses *specific* learning behavior of *all* students (e.g., involvement in group work). In this manner, Fig. 9 illustrates how gamification intervention should affect learning behavior to produce balanced gamified intervention.

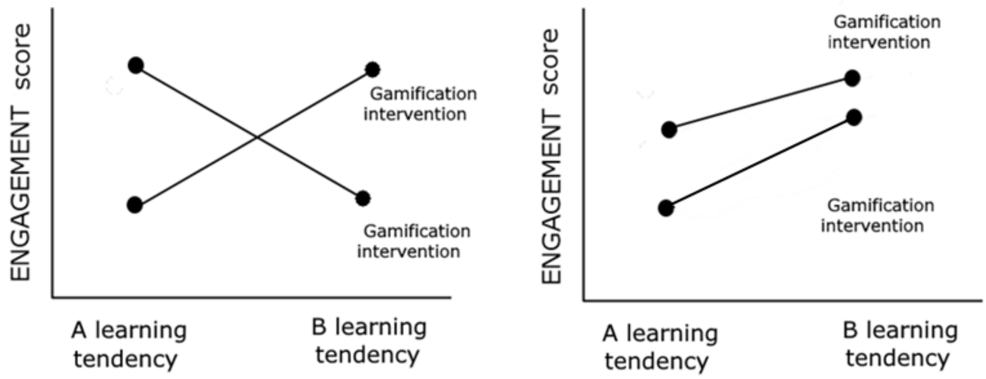


**Figure 9.** *Misbalanced (left) and balanced (right) results of the gamification intervention show that balanced results are obtained only if the intervention boosts mean engagement scores of subjects in both learning tendency groups, having no crossover effects (previously published in [26]).*

Lastly, we should identify a learning-related behavior or attitude – not every learning behavior is relevant for a specific learning outcome. For example, active participation in the course discussion will probably not affect one's motivation, but it could improve the social experience and the feeling of belonging. Thus, gamification should be used to target the behavior that is shown to influence the desirable intent. In this manner, knowledge on learning tendencies can assists identification of learning activities, tasks, and materials, which, when gamified, could lead to targeted behavior. Besides, as the GLT theory itself implies, a designer must be sure that gamification can genuinely change the targeted behavior. For instance, game elements missions and clans can encourage students' collaboration and teamwork in a course. If most students have strong tendencies towards reflective processing (meaning they do not prefer group work), then their involvement in collaborative tasks could be a result of gamification intervention. However, if most students have strong, active tendencies, it would be hard for gamification researchers to claim that gamification encouraged students to participate in group work since active students, by their nature, prefer such activities. In either case, the moderator role of learning tendencies must be noted and taken into account.

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