The Effects of Gamification on Students' Flow Experience: A Controlled Experimental Study

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***Abstract*—Gamification is commonly employed to support the formation of positive psychological states and learning outcomes, with one of the primary psychological factors chiefly relevant to learning being the flow state. However, the effects of gamification on students' flow experience are still little known. Filling this gap, we conducted a between-subjects controlled experiment (N = 65) to analyze the effects of gamification on students' flow experience. Using descriptive and inferential statistical techniques, we compared the flow experience between participants who used a gamified version of an educational system (experimental group) and a group that used the same system without gamification (control group). The main results indicate that the employed gamification design did not affect students' flow experience. Our study contributes especially to educational technologies and gamification fields, demonstrating that gamification may not affect students' flow experience.**

***Index Terms*—Gamified education, flow experience, student experience, learning technologies, controlled experiment**

I. Introduction

Flow, a state of optimal experience characterized by immersion in an activity [1], is widely recognized as a cornerstone of learning [2]. When individuals achieve flow during a task, they become fully absorbed in the task, experiencing effortless action [3]. This state of deep involvement leads to heightened motivation, improved focus, and a deeper comprehension of the material being learned [4]. Numerous studies have established a positive relation between flow experience and learning outcomes [5]–[7].

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At the same time, gamification (*i.e.*, "the design that provides motivational benefits similar to those games usually create" [8], [9]), has significantly grown as an area of pedagogy and in educational technology [10]. Gamification is expected to support positive motivational development among learners in the long term but also may help in-situ learning through better foundational cornerstones of what is often referred to as the flow state [3], [9], [11]. However, while extensively explored in recent studies, the effects of gamification on students' flow experience are still little known [11].

In this study, we examine the effects of gamification (*i.e.*, a single gamification design composed of 10 different gamification elements based on Self-Determination Theory [12]) on students' flow experience. We conducted a between-subjects controlled experiment (N = 65) comparing the flow experience of students who interacted with a gamified educational system (experimental group) to that of students who used the same system without gamification (control group). Utilizing descriptive and inferential statistical techniques, we assessed the differences in flow experience between the two groups.

Our findings indicate that while students in the gamified group indeed experienced a higher level of flow than those in the control group, the employed gamification design did not affect students' flow experience. This suggests that the specific combination of 10 gamification elements implemented in this study may not be sufficient to induce a significantly heightened flow experience among the students. Nevertheless, our study contributes to the growing body of literature exploring the relationship between gamification and Flow Theory, providing valuable insights for educators seeking to optimize learning experiences through gamification.

II. Background and Related Work

Gamification (*i.e.*, the design of systems, services, and activities to provide motivational benefits similar to those games usually create [9], [13]), has emerged as a promising approach to enhancing engagement and motivation in various contexts, including business, corporate management, wellness initiatives, and education [9]. In education, gamification garners increasing attention due to its potential to enhance learner engagement through game elements such as rewards and competition [14].

Following meta-analytical work, gamification appears to be a tremendous potential pedagogical approach, stimulating and maintaining student engagement [9]. However, there may be caveats such as specificities in the design of the implemented gamification that affect the effectiveness of competition hinges on the perception of the reward system's fairness and transparency [15]. While research generally shows positive correlations between gamification and learning outcomes like motivation and self-efficacy [16], [17], results, in general, are mixed [18], [19], indicating a need for further investigation in different educational settings [9].

The gamification design is a crucial factor related to gamification [12]. As an example, autonomy refers to the individual's sense of control over their learning activities and competence refers to the individual's belief in their ability to complete the task at hand successfully [20]. Gamification can be designed to enhance both autonomy and competence [21], [22]. Studies have shown that autonomy-based gamification elements, such as choice, can increase students' perceived autonomy and promote flow experience [21], while competence-based gamification elements, such as challenges and rewards, can enhance students' perceived competence and contribute to flow [22]–[24].

Flow Theory, conceptualized by Csikszentmihalyi [1], describes an optimal psychological state where individuals are fully immersed in an activity, experiencing deep enjoyment and engagement [1], [4], [25]. This state, often referred to as "being in the zone", occurs when there is a balance between the perceived challenges of a task and the individual's skills [4]. In educational contexts, achieving flow is crucial, as it correlates with increased motivation, enhanced learning, and improved performance. Flow is composed of nine different sub-factors (*i.e.*, *i)* challenge-skill balance; *ii)* unambiguous feedback; *iii)* clear goals; *iv)* action-awareness merging; *v)* total concentration on the task at hand; *vi)* sense of control; *vii)* loss of self-consciousness; *viii)* transformation of time; and *(ix) autotelic* experience [4]).

Educators aim to facilitate flow by designing learning activities that are neither too challenging nor too simple, thereby maintaining student engagement [2]. Recent studies have investigated the relationship between gamification and flow [11], [26], [27]. Despite the various studies involving Flow Theory and Education, one of the main challenges remaining related to Flow Theory in education is to analyze what approaches can bring a flow experience [3], [28], [29].

Several studies have delved into examining the relationship between flow experience and the implementation of gamification. Marinho *et al.* [30] in a mixed method study explored students' disengagement, examining how individual player profiles might impact the students' flow experience. The main results did not indicate significant differences in the students' flow experience in the proposed configurations [30]. Oliveira *et al.* [26], [31] investigated in a quantitative study the impact of tailored gamification on elementary school students' flow experience in an educational setting (*i.e.*, comparing tailored and counter-tailored versions of a gamified educational system). The main results did not indicate effects between personalization and students' flow experience [26], [31]. Zhao and Li [27] explored the efficacy of gamification in enhancing students' flow experience in mathematics classes. The research, conducted within a primary school setting, evaluates how educational games affect learners' engagement and performance in mathematics. The results indicate that the game setting can improve students' flow experience.

While previous studies have explored the effects of gamification on students' flow experience from different perspectives, the results are incipient and contradictory. This situation generates a lack of knowledge about the effects of gamification on students' flow experience. To the best of our knowledge, we are the first to conduct a between-subjects controlled experimental study examining how gamification (considering a single combination of 10 gamification elements) influences students' flow experience.

III. Study Design

In this section, we present the study's design.

A. Materials and method

To conduct the study, we used the gamified educational system Eagle-edu[1]. This system was chosen due to its versatility in enabling teachers to create different types of educational activities. Comprising 21 different gamification elements (aligned with the Taxonomy of Gamification Elements for Educational Environments (TGEEE) proposed by Toda *et al.* [32]), these elements can be selectively activated or deactivated by teachers, allowing them to craft personalized gamification designs. In our study, we used two different versions of the system: one devoid of gamification elements (for the control group) and another comprising 10 gamification elements aligned with autonomy- and competence-based gamification design approaches (for the experimental group).

This study implemented 10 gamification elements aligned with the taxonomy proposed by Toda *et al.* [33]: **Acknowledgment** (feedback that praise players' specific actions and represented in the system by the student's badges display); **Chance** (characteristics of randomness and probability to increase or decrease the chances of certain actions or outcomes and represented in the system by different types of choices to make, *e.g.*, choosing between chests); **Competition** (when two or more players compete with each other for a common goal and represented in the system by a ranking (*leaderboards* with up to 10 students)); **Economy** (transactions within the game, monetizing game values, and other elements and represented in the system by coins that can be used to make in-game purchases); **Imposed choice** (decisions that the player is

[1]https://eagle-edu.com.br/

required to make to advance the game and represented in the system by the random option offered to the user to increase their prize); **Level** (hierarchical layers present in a game that provide a gradual way for the player to gain new advantages as their progresses and represented in the system by phase (*i.e.*, Bronze, Silver, Gold, Ruby, and Diamond)); **Objective** (quantifiable or spatial, short to long term and represented in the system by a quest tree); **Point** (units used to measure user performance and represented in the system by experience points (XP)); **Progression** (actions allowing players to locate (and their progress) within a game and represented in the system by a progress bar in the activity tree); and **Stats** (visible information used by the player, related to his game results and represented by all user progress information).

The system's educational activities are composed of three different missions: *i)* general knowledge *ii)* logical reasoning and *iii)* English language. Each mission was made up of five tasks. Students were free to choose where to start and what to do within the time of the experiment. We intentionally chose to organize educational activities in this way to avoid threats related to students' preference for a specific subject. The activities were created by a teacher with experience in the subjects. Both versions of the system (*i.e.*, with and without gamification) were exposed to the same educational activities.

To assess participants' flow experience, we used the Short Flow Experience Scale (FSS) [34], which consists of nine questions representing the nine original flow experience dimensions proposed by Csikszentmihalyi [1], namely: challenge-skill balance, action-awareness merging, clear goals, sense of control, total concentration, transformation of time, feedback, loss of self-consciousness and autotelic experience. The questionnaire was chosen because according to Oliveira *et al*. [2], it is the most used questionnaire in studies related to Flow Theory and technologies in education. Psychometric research has demonstrated sophisticated confirmatory analysis to measure the internal consistency of the FSS [35]. Following the "Flow Experience Manual" [25], the instrument was applied through a five-point Likert scale [36]. To mitigate threats to validity related to the participants' attention during the study, following the recommendation of Kung *et al*. [37], we added an "attention check statement" requesting a specific response - "Please, mark the option 'Agree', to let us know that you are paying attention". Data were analyzed using SPSS software.

The study involved three key steps. *First*, participants were randomly assigned to either the experimental or control group. *Second*, participants used the system for at least 30 minutes, engaging in completing the educational tasks and exploring the system. *Third*, participants responded to the short FSS (immediately after finishing using the system) to identify their flow experience when using the system.

B. Participants and data analysis

To ensure a statistically sound sample size for this study, we chose to use the "*a-priori* sample size calculation" technique [38]. Due to the absence, to the best of our knowledge, of comparable experiments, we aimed to detect a range of effect sizes spanning from low to large (specifically, effect sizes of d = 0.8 or higher, corresponding to a difference of at least half a standard deviation [38]). According to a power analysis performed in GPower [39], a two-tailed paired Mann-Whitney U Test would require a total sample size of 27 to reliably (with a power of 0.80) detect a minimum effect size of 0.8 with a maximum α of 0.05.

Participants were recruited via Tampere University DMLab pool, utilizing ORSEE3 software for coordination [40]. Of the initial pool, three participants were excluded due to a wrong answer in the "attention check statement". The final sample was composed of 65 students from 19 countries, 34 identified themselves as female, 28 as male, two as non-binary and one preferred not to respond. The average age of the participating students is 25 years old, with a standard deviation of 6.00 and a variance value of 33.00. Each participant received 8.00 euros as compensation for their participation. All research procedures were conducted in strict adherence to the guidelines established by the Finnish National Board on Research Integrity (TENK).

To ensure the selection of appropriate statistical tests, we began by assessing the distribution of the collected data. Given the ordinal nature of the data, obtained through a scale, and the sample size of N = 65, we employed the Shapiro-Wilk test [41], a well-established method for normality assessment that is particularly suitable for samples of this size [42]. The results of the test yielded a W statistic of 0.962 and a *p-value* of 0.043, leading us to reject the null hypothesis of normality and conclude that the data exhibited a non-normal distribution. Thus, we opted for the non-parametric Mann-Whitney U test [43] to compare the means between the experimental (gamified) and control (non-gamified) groups. This test is well-suited for our analysis as it offers robustness against violations of normality assumptions and maintains reliability even with small sample sizes [42].

IV. Results

To initially characterize our sample and facilitate subsequent group comparisons, we calculated descriptive statistics, including measures of central tendency (*i.e.*, mean) and variability (variance (VAR) and standard deviation (SD)) for the students' flow experience in both, experimental (gamified) and control (non-gamified) groups. Participants flow experience was calculated based on the average of the nine items, as recommended in the "flow experience Manual" [25]. A summary of the descriptive statistics is presented in Table I.

TABLE I
Descriptive analysis of students' flow experience in the control and experimental groups

Group	Mean	VAR	SD
Control	3.697	0.347	0.580
Experimental	3.858	0.337	0.571
Overall	3.776	0.343	0.581

Key: Var: variance; SD: Standard deviation.

Then, we conducted a Mann-Whitney U test to examine potential differences in flow experience between gamified and non-gamified educational systems. The results (see Table II) demonstrated that while students in the experimental (gamified) group exhibited a numerically higher flow experience score than those in the control (non-gamified) group, the difference was not significant (U = 453.000, Z = -0.987, $p < 0.324$). The associated effect size was also small (r = 0.12), suggesting a limited practical impact of gamification on flow in this context [42].

TABLE II
INFERENTIAL ANALYSIS

Group	**N**	**M**	**S**	**U**	**Z**	***p***	**r**
Control	33	30.73	1014.00	453	-0.987	0.324	0.12
Experimental	32	35.34	1131.00				

Key: N: Number of participants; M: Mean rank; S Sum of ranks; U: Mann-Whitney U; Z: Z score; *p*: *p-value*; r: r-value.

A. Discussion

This study investigated the impact of gamification on students' flow experience. Students in the gamified group reported higher flow scores compared to the control group. However, this difference was not significant (see Table II). These results may defy expectations set by existing literature regarding the advantages of gamification in enhancing the flow experience [27].

Meanwhile, previous studies have recognized the diverse effects of gamification on participants' flow experience [26], [31], indicating that the relationship between these two elements may be intricate and contingent upon various contextual factors. The absence of statistical significance prompts the question of why, despite the apparent enhancement in the flow experience, a statistically significant difference between the groups could not be established.

Uncontrolled factors, *e.g.*, individual characteristics of the participants, or specific aspects of gamification implementation, may have influenced the results. The dichotomy between the subjectively perceived improvement in the flow experience and the lack of statistical significance underscores the imperative to refine our theoretical understanding of the nuanced ways gamification interacts with individual and contextual factors to influence students' learning experience.

B. Threats to validity and limitations

Some threats to validity and limitations must be carefully considered when interpreting and generalizing the results. The study was conducted with a relatively small sample of 65 participants, which may limit the generalization of the results to a wider population, potentially influencing the representativeness of the data, and compromising the external validity and the ability to extrapolate the results to more diverse educational contexts.

The experiment was carried out in a specific educational environment, and the results may not be directly transferable to other educational contexts. Also, the definition and implementation of gamification elements can vary. In the present study, gamification was applied in a specific way, and the effects may be sensitive to the specific characteristics of the elements used. This may also have directly influenced the flow experience, as some elements may lead to a feeling of anxiety, which may have negatively affected the flow experience. Additionally, students in an experimental setting may behave differently than they would in real-world learning scenarios.

While the study focused primarily on the direct effects of gamification on flow, individual factors such as prior gaming experience and learning preferences may act as moderating variables, influencing how students respond. We addressed potential limitations by utilizing techniques like randomization in participant group assignment and appropriate statistical analysis methods.

C. Recommendations for future studies

Based on the results of our study, as well as in the perceived limitations, it is possible to propose some points to be considered in future studies. **Utilizing extensive and diverse samples in future research will enable a more generalizable analysis of the effects of gamification on the flow experience, encompassing a wider range of student profiles and educational environments**. This broader understanding can inform the development of effective gamification strategies applicable to more varied student populations and contexts. Similarly, **longitudinal research can reveal how student motivation and performance evolve in response to gamification, offering insights into long-term effects**.

To unpack the specific elements driving flow in gamified learning, **future research should experiment with diverse gamification strategies, manipulating core components like rewards, challenges, and feedback**. Instead of simply exploring gamification's broad effects, **future research should investigate individual differences**. Identifying moderating variables, such as prior gaming experience or learning preferences, can reveal how students respond uniquely to gamification approaches.

V. CONCLUDING REMARKS

This paper explored the effects of gamification on students' flow experience through a between-subjects controlled experiment. While the observed difference in flow between the gamified and non-gamified groups did not reach statistical significance, there was a suggestive trend toward higher flow scores in the gamified group. To further explore these nuanced effects, future studies will replicate the study with a larger sample to increase statistical power, as well as analyze different gamification designs and investigate potential moderating variables, such as individual learning preferences.

APPENDIX

The study dataset can accessed from this link: https://osf.io/97nu4/

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