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Digital Gamification and Visual Modeling for Learning Regulation in Biomedical Education

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Abstract

Learning regulation is a central determinant of student achievement and autonomy in higher education. Grounded in Self-Determination Theory, this quasi-experimental study examined the effects of a seven-week intervention in biomedical education that combined visual modeling through drawing with gamification elements supported by digital tools (ClassDojo, 3D atlases, augmented reality). Participants were 116 first-year anatomy students from two universities, one receiving the experimental treatment (visual modeling with gamification) and the other serving as a control group (traditional instruction). Pre- and post-intervention measures were collected using the Self-Regulation of Learning Questionnaire to assess changes in autonomous regulation (AR), controlled regulation (CR), and the Relative Autonomy Index (RAI). Results showed no significant effects on AR, while CR was significantly higher in the experimental group. A treatment effect was also found for the RAI, although no evidence of motivational internalization toward more autonomous regulation emerged within the short intervention. This study highlights how gamified digital platforms can serve as tools for media literacy in higher education, fostering critical engagement with technology as a component of lifelong learning. Findings suggest that combining gamification with visual modeling reinforces controlled regulation, while longer and more autonomy-supportive interventions may be required to foster sustainable autonomous regulation.

Keywords: digital platforms; emerging technologies; augmented reality; gamification; pedagogical approaches; educational methodologies; anatomy education; autonomous regulation; controlled regulation; lifelong learning

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1. Introduction

An autonomous learner takes responsibility for their own learning, deciding what information to acquire and how to process it, rather than acting as a passive recipient of knowledge (Orakcı, 2021). This conception is closely linked to self-regulated learning, which refers to learners' ability to monitor and control their performance to achieve academic and personal goals (Garello & Rinaudo, 2012). Empirical research across educational levels has consistently demonstrated the benefits of self-regulated learning interventions. In primary education, these strategies significantly enhance both learners' regulatory skills and academic achievement (Olid-Luque et al., 2025). In higher education, self-regulated learning has been associated with deeper learning, improved performance, and greater study satisfaction (Šteh & Šarić, 2020), while recent meta-analytic evidence in medical education shows positive and significant relationships between self-regulated learning strategies and learning outcomes, with stronger effects on affective engagement than on test performance (Zheng & Sun, 2024). Comprehensive reviews further highlight that strategies involving self-regulation and self-assessment are critical for both academic and emotional success (Liu et al., 2025).

However, the literature offers varying interpretations of how self-regulated learning operates and develops. From the viewpoint of distributed cognition (Flor & Hutchins, 1991; Hutchins, 1990), regulation is not limited to individual processes but extends to social dimensions, where peers and teachers serve as co-regulators (Šteh & Šarić, 2020). In contrast, other researchers describe self-regulated learning as a primarily internal and dynamic process occurring within the learner (Hardy et al., 2019). Both approaches, nevertheless, underscore the crucial role of educators in creating collaborative environments that foster reflection, feedback, and self-evaluation.

Within this framework, Self-Determination Theory (SDT) offers a conceptual foundation for distinguishing between autonomous and controlled forms of regulation, the former guided by interests and internalized values and the latter driven by external pressures or rewards (Deci & Ryan, 2000; Ryan & Deci, 2017). In accordance with this theoretical perspective, the present manuscript uses the term "motivation" to denote the underlying psychological orientation that energizes behavior, and "regulation" to describe the behavioral expression of that motivation along a continuum from controlled to autonomous forms. These two levels are considered jointly to examine how external and internal forces shape students' learning engagement.

Self-Determination Theory posits that autonomous motivation fosters more adaptive functioning than controlled motivation (Deci & Ryan, 2000; Vansteenkiste et al., 2004). In educational settings, autonomy-driven motivation has been consistently associated with greater persistence, improved performance, and enhanced well-being compared to controlled motivation (Grolnick & Ryan, 1989). Empirical research additionally shows that this motivational orientation is associated with teachers' well-being, job satisfaction, and autonomy-supportive practices (Slemp et al., 2020), as well as with students' higher perceived competence, increased interest and enjoyment, and lower anxiety (Black & Deci, 2000). It has also been linked to adaptive perfectionism, contrasting with the maladaptive patterns typically related to controlled motivation (Vansteenkiste et al., 2010).

At the same time, SDT further emphasizes that the degree of internalization of extrinsically motivated behaviors can vary among individuals. Specifically, four types of behavioral regulation are distinguished: external regulation and introjected regulation (considered more controlled), and identified regulation and integrated regulation (considered more autonomous) (Deci & Ryan, 2000). Within this continuum, external reinforcements such as point rewards can function as initial triggers of engagement, but sustained progress toward more autonomous forms of regulation requires opportunities for reflection and the internalization of motivation.

Research on self-regulated learning highlights pedagogical strategies that contribute to these processes. Garello and Rinaudo (2012) underline the importance of reflection on practical problems, integration of prior knowledge, constructive feedback, and revision of work, while Schraw et al. (2006) propose strategies in science education such as inquiry-based learning, collaborative support, problem solving, and the construction of mental models. These strategies are closely aligned with reflective and metacognitive components embedded in drawing-based modeling.

In recent years, gamification has emerged as a complementary approach to enhance motivation and self-regulated learning. However, while some studies report significant improvements in motivation and autonomy (Li et al., 2022; Chen et al., 2024), others highlight modest or context-dependent outcomes, stressing that the design of the intervention is critical (Zambrano-Álava et al., 2020). Meanwhile, representational modeling activities like drawing have been shown to support metacognitive monitoring and self-assessment (Schleinschok et al., 2017).

Beyond their motivational role, digital technologies—such as learning management systems, collaborative platforms, and artificial intelligence tools—can mediate learning regulation by providing adaptive feedback, supporting metacognitive monitoring, and fostering autonomous engagement (Faza & Lestari, 2025). In line with this perspective, the present study integrated digital gamification as a pedagogical approach to enhance students' learning regulation in anatomy. Platforms such as ClassDojo, 3D atlases, and augmented-reality tools were employed as interactive environments that facilitated feedback loops, visual modeling, and personalized reinforcement. This combination illustrates an innovative educational use of technology, linking digital interaction with the cognitive and motivational processes underlying anatomy learning.

In this regard, the study can also be framed within Media and Information Literacy, defined as the set of technical, cognitive, social, civic, ethical, and creative competences required to access, analyze, evaluate, and create media content critically and responsibly, as well as to engage in lifelong learning (Alcolea-Díaz et al., 2020). From this perspective, self-regulated learning involves not only managing motivation and strategies but also cultivating an autonomous and critical engagement with digital platforms.

Gamification can therefore be understood as a pedagogical means of fostering media literacy, as it enables students to interpret, create, and respond within digital environments while applying educational competences. By engaging in gamified activities through platforms such as Quizizz, ClassDojo, or Moodle, learners develop habits of critical interaction with digital media, strengthening their capacity for lifelong learning and digital citizenship (Swacha, 2022).

Combining these two didactic approaches—drawing-based modeling and gamification—within a media literacy framework provides a valuable foundation for examining how external reinforcements and reflective activities might jointly shape students' motivational regulation in anatomy education.

This study aimed to examine the effects of a seven-week educational program in anatomy that integrated reflective drawing with reinforcement through gamification elements on students' self-regulation of learning, with a particular focus on autonomous and controlled regulation.

Specifically, the study addressed the following research questions:

(1) Does a seven-week educational intervention combining drawing-based modeling and gamification through digital technologies produce significant changes in students' autonomous regulation?
(2) Does this intervention affect controlled regulation, reflecting shifts in external engagement and motivational control?
(3) To what extent does the intervention influence the overall motivational balance, as reflected in the Relative Autonomy Index (RAI)?
(4) How can these effects be interpreted in light of Self-Determination Theory and Media and Information Literacy, particularly regarding motivational internalization and autonomy support within digitally mediated learning environments?

2. Materials and Methods

2.1. Participants and Sampling

The study was conducted in two Spanish public universities located in different cities. The institutions were selected using convenience and purposive criteria: both were public, offered the Bachelor's Degree in Physical Activity and Sport Sciences, and were accessible to the research team (one being their home institution, while the other agreed to collaborate).

Within each university, all students enrolled in the first semester of the first year were invited to participate, aiming to reach the entire accessible population. Participation was voluntary, and students were informed about the study's objectives, procedures, and confidentiality assurances prior to providing informed consent. The study received ethical approval from the Clinical Research Ethics Committee of Aragón (Spain) on 7 September 2022 (statement number: PI22/383).

Although 205 students (81 from the University of Zaragoza and 124 from University of Lleida) initially participated in the study by completing at least one questionnaire (pre- or post-test) and attending some classes, only those who completed both questionnaires and followed the full instructional program were included in the final analysis. Based on this criterion, the analytic sample comprised 116 students: 60 from the University of Zaragoza (n = 14 women; n = 46 men) and 56 from the University of Lleida (n = 13 women; n = 43 men). The mean age of the final sample was 19.00 years (SD = 1.96), with university-specific means of 18.65 (SD = 1.25) for the University of Zaragoza and 19.38 (SD = 2.47) for Lleida.

2.2. Research Design and Procedure

A quasi-experimental pretest–posttest design with a control group was applied. This design ensured ecological validity while maintaining control over the educational interventions.

Each university was assigned to one treatment condition: one served as the experimental group (University of Zaragoza), while the other acted as the control group (University of Lleida). The intervention was implemented during the first semester of the first academic year. Each intervention was delivered by a different teacher and spanned seven weeks as part of the regular human anatomy curriculum at each university.

The sequence was as follows: students completed a pre-test before the intervention (September 2022), received the instructional treatment across the semester, and then completed a post-test at the end (November 2022).

2.3. Instructional Treatments

2.3.1. Experimental Treatment

The experimental group received an educational program based on modeling through the "observe–reflect–draw–edit–repeat" method described by Backhouse et al. (2017). Each phase was adapted to the contents, using visual stimuli (e.g., videos, images, 3D atlases, augmented reality cubes, Instagram-like filters) to present a problem for each human system, and drawing or editing activities to solve it and construct mental models. To complement these activities, ClassDojo (ClassDojo Inc., San Francisco, CA, USA) was used in two ways: first, as a gamification and reinforcement system to assign point rewards for specific academic behaviors that instructors sought to strengthen (such as attentive participation, collaboration, accurate responses in class discussions, or evidence of previous study). These points contributed to the students' final grade, thus connecting digital engagement with academic evaluation. Second, ClassDojo acted as an internal class social network where instructors uploaded brief stories, allowing students to interact through comments and reactions.

Feedback practices were incorporated continuously throughout the sessions. The instructor circulated among students, observing their progress and providing immediate reinforcement through ClassDojo whenever particular behaviors or task-related achievements were detected (e.g., active teamwork, successful problem solving, or self-correction of drawings). Additionally, the digital platform Quizizz (Quizizz Inc, Bangalore, India), was used during the "review" phase of the ORDER cycle to consolidate learning through game-based quizzes, offering instant feedback that reinforced both participation and comprehension.

This integration of gamification, continuous digital feedback, and visual modeling aimed to increase engagement while fostering metacognitive reflection and self-regulation in a dynamic, technology-mediated learning environment.

2.3.2. Control Treatment

The control group followed a lecture-based instructional approach. This lecture-based approach corresponds to the standard format of anatomy instruction in Spanish universities, combining teacher exposition with note-taking and atlas-based exercises. Students in the control group also practiced basic drawing activities, although without structured modeling cycles or gamified reinforcement. Therefore, the control treatment represented the traditional, content-focused mode of instruction typically used in first-year anatomy courses.

2.3.3. Instructional Contents

In both universities' curricula for the Bachelor's Degree in Physical Activity and Sport Sciences, Human Anatomy is taught in the first semester of the first year. Accordingly, both groups received instruction on foundational topics, including general anatomy, anatomical terminology, anatomical position, and body axes and planes. Beyond these shared elements, curricular structure and logistical factors led to differences: the experimental treatment addressed multiple body systems and organs (circulatory, respiratory, digestive, excretory, reproductive, endocrine, and nervous), whereas the control treatment focused specifically on the musculoskeletal system.

2.4. Data Collection Instruments

In this study, 116 participants completed an online questionnaire that included demographic and academic questions to control relevant covariates, as well as a scale to assess self-regulated learning. The Self-Regulation of Learning Questionnaire (SRQ-L; Williams & Deci, 1996) was used to evaluate students' motivational orientation. Although the instrument measures two aggregated categories—autonomous regulation (identified and intrinsic) and controlled regulation (external and introjected)—these correspond conceptually to the orientations of autonomous motivation and controlled motivation described in Self-Determination Theory (Ryan & Deci, 2017). Accordingly, both terms (motivation and regulation) are used in the manuscript to distinguish the theoretical constructs of SDT from their operational assessment in the SRQ-L.

The SRQ-L contains 14 items, divided into two subscales of 7 items each—Autonomous Regulation (AR) and Controlled Regulation (CR)—which can be analyzed independently or combined to calculate the Relative Autonomy Index (RAI).

Participants rated each item on a 7-point scale, ranging from 1 ("completely disagree") to 7 ("completely agree"). Scores for each subscale were calculated by averaging the relevant items, and RAI was calculated by taking the difference between AR and CR scores. In previous studies, the alpha reliabilities for AR and CR have been approximately 0.80 and 0.75, respectively (Black & Deci, 2000; Williams & Deci, 1996).

In the present study, internal consistency indices were Cronbach's α = 0.840 and McDonald's ω = 0.851 for AR, α = 0.579 and ω = 0.622 for CR, and α = 0.801 and ω = 0.810

for the RAI. The lower reliability of the CR subscale can be partially attributed to the short length of the subscale (7 items), which generally reduces alpha and omega values even when items are reasonably consistent. According to Cortina (1993, p. 102), if a construct has fewer than 10 items, a Cronbach's α greater than 0.5 is considered acceptable, while constructs with more than 10 items should ideally have $\alpha \geq 0.7$. Therefore, despite the lower alpha for CR, it is acceptable in this context, and the combination into the RAI improves overall consistency.

2.5. Data Analysis

Partial data collection was eliminated, meaning that participants who only filled in either the pre-measure or the post-measure were excluded from the analysis. For participants who completed the study (both pre- and post-measures), a preliminary analysis was conducted to assess normality and homogeneity and to identify and remove outlier responses for each variable. Outliers were identified using SPSS stem-and-leaf plots. Extreme values flagged by the software were removed on a variable-wise basis, which resulted in varying sample sizes across variables and time points.

The final data analysis was then performed for each variable after excluding the outliers.

The baseline differences between groups were compared in each variable by using student's *t*-test for independent samples.

After the intervention, Student's *t*-test for independent samples was applied. The effect size was calculated using Cohen's d. The following interpretation of the effect size has been followed: small ($d \geq 0.2$), medium ($d \geq 0.5$), and large ($d \geq 0.8$) (Cohen, 1988).

In the study, the two groups were compared using repeated measured factorial ANCOVAs 2 $\times$ 2, which includes two factors: time (pre-test vs. post-test) and treatment (drawing-based modeling with gamification vs. lecture-based instruction without gamification). This statistical analysis allows for a comprehensive examination of the effects of both time and treatment on the study variables. Relevant covariates were controlled for each variable. The effect size was calculated by partial eta-squared ($\eta^2{}_p$). The following interpretation of the effect size has been followed: small ($\eta^2{}_p \geq 0.0099$), medium ($\eta^2{}_p \geq 0.0588$), and large ($\eta^2{}_p \geq 0.1379$) (Cohen, 1988, pp. 278–280; Richardson, 2011). The analysis threshold was set at $\leq$0.05. All the statistical analyses were performed using IBM SPSS Statistics (version 26.0).

For each dependent variable, relevant covariates were examined, and those showing significant correlations were considered in subsequent analyses. Specifically, for autonomous regulation, age, pre-test cognitive flexibility (assessed with the Cognitive Flexibility Scale; Martin & Rubin, 1995), weekly study hours, self-reported autonomous engagement in studies, and drawing while taking notes were included. For controlled regulation, the covariates were self-reported autonomous engagement in studies, and weekly study hours. For the Relative Autonomy Index, age, drawing while taking notes, sports practice, and pre-test cognitive flexibility were considered. All covariates showing significant correlations were initially included in the models; non-significant covariates were subsequently removed to optimize model fit.

3. Results

3.1. Descriptive Statistics

Descriptive statistics, including means and standard deviations for each treatment and variable, are presented in Table 1.

Table 1. Descriptive Statistics: Comparison of variables between Control and Experimental Treatments.

Variables	Control Treatment		Experimental Treatment	
	Baseline	**Follow-Up**	**Baseline**	**Follow-Up**
Autonomous Regulation	42.10 ± 4.36 (48) [1]	41.71 ± 4.98 (48)	41.17 ± 4.76 (53)	40.83 ± 4.94 (53)
Controlled Regulation	22.78 ± 4.20 (54)	23.02 ± 4.76 (54)	24.42 ± 6.29 (60)	25.23 ± 5.36 (60)
Relative Autonomy Index	17.84 ± 6.26 (50)	17.62 ± 6.40 (50)	14.57 ± 6.14 (60)	14.63 ± 5.48 (60)

[1] Values are M ± SD (n). Sample sizes vary by cell due to variable-wise extreme outlier removal based on SPSS stem-and-leaf plots.

3.2. Baseline Comparison Between Groups

No significant baseline differences were found between the two groups for AR ($p = 0.308$) and CR ($p = 0.109$) using t-test.

However, a significant baseline difference was found for the RAI, $t(108) = 2.759$, $p = 0.007$, MD = 3.27, 95% CI [0.922 to 5.625], $d = 0.51$. This initial difference highlights the need to adjust subsequent analyses for pre-test scores using ANCOVA to obtain more accurate estimates of the intervention effects.

3.3. Autonomous Regulation of Learning

A post-intervention t-test for independent samples showed no significant differences ($p = 0.376$).

A repeated-measures factorial ANOVA (time × treatment) revealed no significant main effects of treatment ($p = 0.275$) or time ($p = 0.438$), nor a significant interaction effect ($p = 0.953$). Moreover, both groups exhibited a non-significant decrease in AR scores between pre- and post-test: the experimental group ($p = 0.590$) and the control group ($p = 0.580$).

After adjusting for relevant covariates (age, $p = 0.001$; pre-test drawing while taking notes, $p = 0.003$; pre-test cognitive flexibility score, $p = 0.009$), no significant main effects of treatment ($p = 0.762$), time ($p = 0.485$), nor interaction ($p = 0.704$), were observed. Covariates initially showing significant correlations with AR were considered, while non-significant covariates were subsequently removed to optimize model fit.

As shown in Figure 1, the estimated marginal means of AR remained relatively stable across the two treatment conditions after controlling for covariates. Although no statistically significant differences were found, the visual pattern suggests a differentiated evolution between groups: while the control group exhibited a steeper decline from pre-test to post-test, the experimental group maintained a more stable trajectory. This tendency may indicate that the intervention helped mitigate the decrease in autonomous regulation over time, potentially leading to an interaction effect in longer interventions. Nevertheless, given the short duration of the program, these indications should be interpreted with caution and regarded as a possible direction for future research.

3.4. Controlled Regulation of Learning

A post-intervention t-test for independent samples showed that the experimental treatment group had higher CR scores than the control group ($t(112) = 2.324$, $p = 0.022$, MD = 2.22, [95% CI, 0.326 to 4.103]), with a medium effect size ($d = 0.43$).

A repeated-measures factorial ANOVA (time × treatment) demonstrated a significant treatment effect ($F(1) = 5.167$, $p = 0.025$, MD = 1.927, [95% CI, 0.247 to 3.606]) with a small effect size ($\eta^2_p = 0.044$). No time effect ($p = 0.292$) or interaction effect ($p = 0.566$) was found.

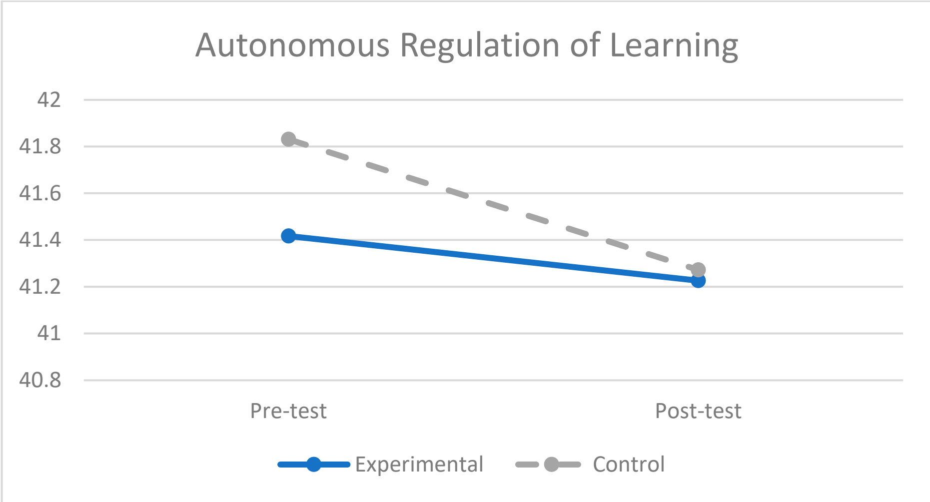

Figure 1. Estimated marginal means of Autonomous Regulation across treatment conditions, controlling for covariates (age, pre-test drawing while taking notes, and pre-test cognitive flexibility). Note: the *Y*-axis has been rescaled to enhance visualization of differences.

Even after controlling relevant covariates (self-reported autonomous engagement in studies and weekly study hours), the treatment effect remained significant ($F(1) = 4.012$, $p = 0.048$) with a small effect size ($\eta^2{}_p = 0.035$), although these covariates were not significant in the adjusted model ($p = 0.176$ and $p = 0.228$, respectively). In this model, no time ($p = 0.464$) or interaction effects ($p = 0.584$) were observed.

In summary, the analysis revealed a significant treatment effect on Controlled Regulation.

As shown in Figure 2, the estimated marginal means appear slightly higher in the post-test for both groups, with a more evident increase in the experimental group. This pattern remained significant after adjusting for relevant covariates, whereas no time or interaction effects were found. The result suggests that the gamified reinforcement system effectively enhanced externally driven engagement among students exposed to the experimental condition, consistent with the idea that reward contingencies and feedback mechanisms primarily activate controlled forms of motivation rather than fostering internalized regulation.

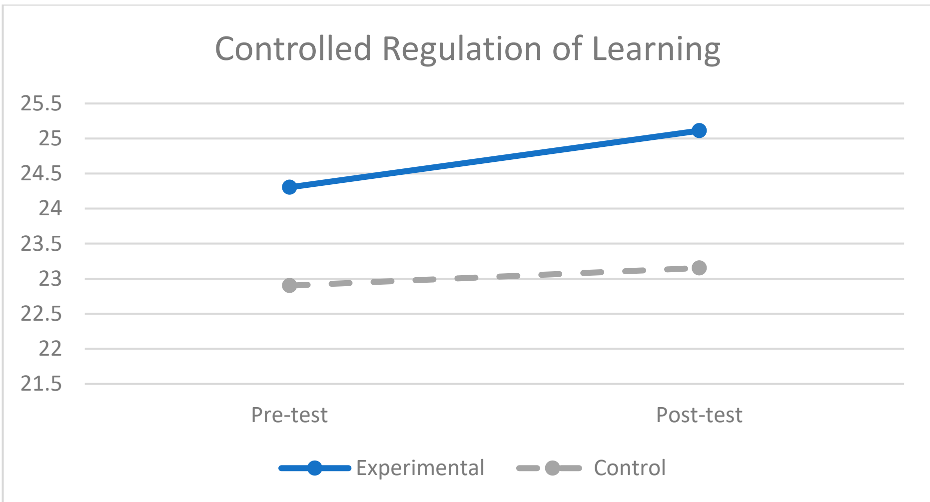

Figure 2. Estimated marginal means of Controlled Regulation across treatment conditions, controlling for covariates (self-reported autonomous engagement in studies and weekly study hours). Note: the *Y*-axis has been rescaled to enhance visualization of differences.

3.5. Relative Autonomy Index

Baseline RAI scores differed between groups, so post-test analyses controlled for pre-test scores. A post-intervention t-test for independent samples showed that the experimental treatment group had lower RAI scores than the control treatment group ($t(108) = 2.6$, $p = 0.01$, MD = 2.98, [CI 95%, 0.741 to 5.232]), with a medium effect size ($d = 0.49$).

A repeated-measures factorial ANOVA (time × treatment) revealed a significant main effect of treatment ($F(1) = 10.114$, $p = 0.002$, MD = 3.13, [95% CI, 1.179 to 5.081], $\eta^2{}_p = 0.086$). Even after controlling significant covariates (age, $p = 0.002$; pre-test drawing while taking notes, $p = 0.009$; pre-test cognitive flexibility, $p = 0.009$) the treatment effect remained significant (F(1) = 5.292, $p = 0.023$, MD = 2.116, [95% CI, 0.292 to 3.940]), with a small effect size ($\eta^2{}_p = 0.048$). No main effect of time ($p = 0.927$) or interaction effect ($F(1) = 0.537$, $p = 0.465$) was observed.

Within-group comparisons using t-tests indicated a non-significant increase in RAI scores from pre- to post-test for the experimental group ($p = 0.930$) and a non-significant decrease for the control group ($p = 0.826$).

As shown in Figure 3, this visual pattern reflects a slight divergence between groups: the control group started with higher baseline RAI scores but displayed a mild downward trend, while the experimental group remained stable or slightly improved. Although these variations were not statistically significant, they are consistent with the treatment effect observed in the overall model and suggest that, over a longer intervention period, group trajectories might further diverge, potentially indicating a gradual motivational shift toward more autonomous forms of regulation.

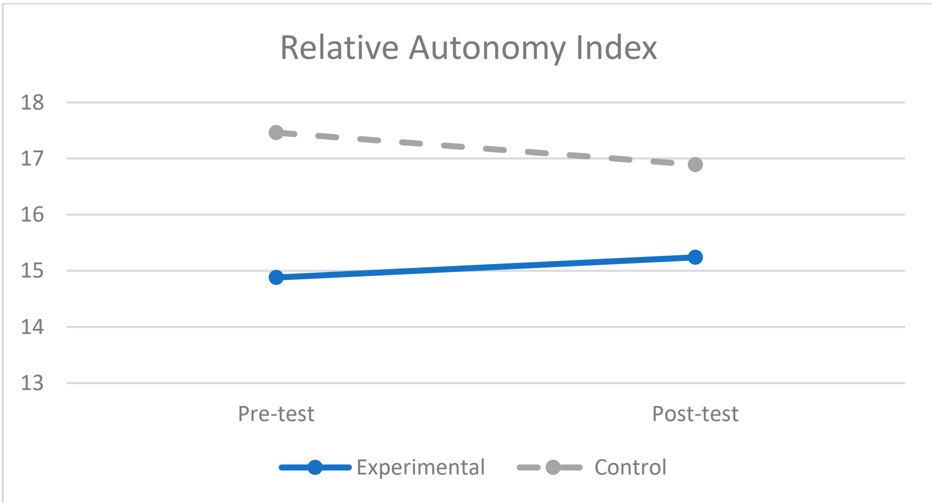

Figure 3. Estimated marginal means of Relative Autonomy Index across treatment conditions, controlling for covariates (age, pre-test drawing while taking notes, and pre-test cognitive flexibility). Note: the Y-axis has been rescaled to enhance visualization of differences.

4. Discussion

The didactic intervention, which combined drawing-based modeling with a reinforcement system using ClassDojo, did not produce significant changes in autonomous regulation. However, the experimental group showed higher scores in controlled regulation than the control group, together with a treatment effect on the Relative Autonomy Index. These findings indicate that the intervention influenced the students' overall motivational profile, as reflected in the Relative Autonomy Index, yet without clear evidence of short-term internalization within autonomous regulation and, consequently, autonomous motivation.

Regarding autonomous regulation, no significant differences were found between groups, nor were there time or interaction effects, even after controlling covariates such as age, cognitive flexibility, and pre-test drawing while taking notes. It is important to note that both groups started from relatively high baseline values for this variable (42.10 ± 4.36 and 41.17 ± 4.76 points out of a maximum of 49), which likely limited the potential for further improvement. Williams and Deci (1996), in a study with 20- and 24-week interventions in health contexts, demonstrated that prolonged programs with autonomy support generate increases in autonomous motivation. In this study, the seven-week duration may have been insufficient to foster a comparable internalization process—the transformation of external rules, values, and motivations into self-endorsed ones—, partly explaining the stability observed in this variable. Moreover, age emerged as a significant covariate, with the control group being older on average than the experimental group, which is consistent with studies showing that autonomy increases with life development and academic experience (Sheldon et al., 2006). Our interpretation suggests that, for first-year students, the emergence of stable forms of autonomous regulation (and consequently the development of autonomous motivation) may depend more on developmental and experiential factors than on short-term instructional interventions. In this regard, the literature indicates that autonomy tends to increase notably in late adolescence (Wray-Lake et al., 2010), which includes much of our sample.

Recent studies further refine this interpretation. Wang et al. (2025) showed that achievement motivation mediates the relationship between personal dispositions and the use of self-regulated learning strategies among university students. In our study, the absence of change in autonomous regulation may reflect that the intervention did not sufficiently activate achievement motivation, understood as the drive to pursue meaningful academic goals (Wang et al., 2025). This component is typically strengthened when tasks are perceived as valuable challenges, connected to personal or professional goals. In our design, the structure of teacher-defined tasks and the use of ClassDojo may have favored the pursuit of external rewards rather than the experience of personal success, thereby limiting the potential development of autonomous regulation.

Other studies confirm that the effectiveness of gamification for self-regulation largely depends on task type. Da Rocha et al. (2023), when comparing gamified and non-gamified groups in Open Learner Models, found no significant differences in self-regulation, suggesting that not all forms of gamification necessarily promote more self-determined learning. Likewise, Papamitsiou and Economides (2019) showed that the impact of self-regulated strategies on autonomy is strategy-dependent: while goal setting and time management foster increases in autonomy, help-seeking may reduce it. In our study, the instructor corrected and returned the experimental group's assignments, a pedagogically valuable practice that might nevertheless have operated as a structured form of help-seeking—one that does not necessarily foster autonomous regulation of learning. Similarly, Paethrangsi et al. (2024) highlight that fostering student autonomy requires promoting skills such as planning, teamwork, self-reflection, and time management with technology. In our intervention, although collaborative and reflective activities were included, the presence of teacher-defined tasks and deadlines linked to continuous assessment, together with the use of ClassDojo, may have limited opportunities for personal choice and diverted students' efforts toward secondary or peripheral aspects, thereby reducing the potential support for autonomy.

In contrast, controlled regulation did show differences between groups: the experimental group obtained higher scores than the control, with a treatment effect attributable to the use of external reinforcements through ClassDojo. This result is consistent with previous findings on gamification. For example, Sailer and Homner (2020), in their meta-analysis, point out that systems based on external rewards, such as points or badges, favor an increase in controlled motivation, generating immediate engagement. Our data support this conclusion: students in the experimental group appeared to experience learning more as an obligation or as a means of gaining external approval. However, according to Self-Determination Theory, "more controlling motivational climates for learning foster external regulation, and the result is more superficial and less transferable learning" whereas "school climates that support autonomy foster more self-motivation, persistence, and quality of learning" (Ryan & Deci, 2017, pp. 17–18). Therefore, although the finding reflects motivational activation, it raises questions about long-term sustainability.

Taken together, these findings suggest that the gamified dynamics of the intervention primarily activated extrinsic engagement through reward contingencies and instructor-mediated feedback (Deci et al., 1999). In practical terms, the immediate reinforcement and public recognition afforded by ClassDojo may have heightened students' responsiveness to external cues, sustaining participation but limiting opportunities for self-assessment and intrinsic reflection. This dynamic likely reinforced externally regulated behaviors, which may explain the relative stability of autonomous regulation despite students' active engagement in gamified tasks. The absence of explicit autonomy-supportive elements—such as volitional choice or self-paced challenges—may have slowed the internalization of motivation into more autonomous forms.

The Relative Autonomy Index provides an integrative view of the motivational profile, as it combines autonomous and controlled regulation. Although the groups differed significantly at baseline, factorial analyses revealed a treatment effect independent of covariates, indicating that the intervention altered the students' overall motivational balance. This result suggests that the Relative Autonomy Index is sensitive to relative variations between the two types of motivation, even when they do not change significantly separately. However, the absence of time and interaction effects suggests that this was not a progressive change, but rather a stable difference linked to the experimental condition. The question remains whether the increase in controlled regulation in the experimental group constitutes an initial stage toward the future internalization of motivation or, conversely, a risk of dependence on external incentives that could limit the development of self-determination and, consequently, self-regulated learning.

Finally, the use of drawing as a modeling strategy in this research deserves attention. Schleinschok et al. (2017) demonstrated that drawing as a generative strategy fosters monitoring and self-assessment of learning, reinforcing metacognitive skills, although its effects on strategic decision-making about one's study appear less consistent. Our data suggest that drawing may have contributed to making comprehension processes visible, although not necessarily to strengthening autonomous regulation of learning. A possible explanation is that the anatomy tasks in the experimental group, focused on organs and systems, did not offer sufficient opportunities for choice or for connecting with immediate personal or professional interests—conditions identified in the literature as central to autonomy support (Ryan & Deci, 2017).

These findings can also be interpreted through the lens of media literacy, as the use of gamified digital platforms required students to engage critically and autonomously with technological environments. Beyond the specific gains in controlled regulation, the intervention functioned as an exercise in digital citizenship, fostering skills to access, analyze, and respond to media content (Danov, 2024).

Beyond its immediate outcomes, the intervention illustrates an innovative application of digital technologies to anatomy education, revealing both the potential and the limits of gamified environments to shape motivational regulation. This duality—technology as both a source of engagement and a vehicle of external control—highlights the importance of pedagogical intentionality in transforming digital tools into environments that genuinely support autonomy and self-regulated learning. From a theoretical standpoint, this convergence between Self-Determination Theory and Media and Information Literacy suggests that digital learning environments mediate extrinsic and intrinsic motivational processes and shape the conditions under which autonomy can be supported. Overall, these observations complement the motivational interpretation of our findings and lead to a broader understanding of how digital contexts interact with students' regulatory profiles.

Taken together, the findings reaffirm what Self-Determination Theory proposes: external rewards can motivate students and increase controlled regulation, but the development of autonomy requires longer interventions and an environment that reinforces choice, personal relevance, and non-controlling feedback. Future programs should incorporate explicit autonomy-support strategies—for instance, offering tasks aligned with students' interests, providing challenges, enabling opportunities for choice, and promoting self-regulation rather than dependence on rewards—to foster a more self-determined and sustainable motivational profile over time.

5. Limitations and Future Directions

While this study provides valuable insights into the effects of a drawing-based modeling intervention supported by ClassDojo, certain limitations should be acknowledged. First, the relatively short duration of the intervention (seven weeks) may not have been sufficient to capture gradual processes of autonomy development and motivational internalization. Future studies could extend the intervention over longer periods, incorporating intermediate assessments to observe more sustained developments in students' regulatory profiles and to examine how autonomy and self-regulated learning evolve over time and across different educational contexts. In addition, it would be informative to explore how course level or task type influences the effectiveness of such approaches. Longitudinal research could also help to clarify whether externally reinforced forms of regulation gradually become internalized or remain mainly dependent on external contingencies such as grades or rewards.

Second, the quasi-experimental design offered ecological validity by taking advantage of a natural educational setting. Nevertheless, complementing such designs with randomized trials in future research would provide stronger internal validity and allow for more robust causal inferences. As is common in educational contexts, certain contextual and interpersonal factors could not be entirely controlled and may have subtly affected the outcomes. These factors should therefore be recognized as potential limitations of the study.

Third, the study contributes to an area where empirical evidence remains limited. While many investigations on self-regulated learning and gamification have focused on medical education, there is comparatively less research in the context of Sport Sciences. These findings begin to address this gap, but further investigations are encouraged to consolidate knowledge in this specific field. Finally, additional research is encouraged to examine the development of self-regulated learning across critical educational transitions—such as the first year of university—and to assess the applicability of current models of self-regulated learning across different developmental stages and contexts (Panadero, 2017).

6. Conclusions

This study examined the impact of a drawing-based modeling intervention supported by a point-based reinforcement system on students' motivational regulation in the context of anatomy learning. The results showed no significant changes in autonomous regulation but revealed higher controlled regulation scores in the experimental group, as well as a treatment effect on the Relative Autonomy Index. These findings suggest that external reinforcement systems can influence students' overall motivational profiles in the short term, although without clear evidence of internalization processes within a seven-week period.

The study highlights the importance of considering both autonomous and controlled regulations when evaluating gamification strategies in higher education. While external rewards may enhance immediate engagement, fostering sustainable autonomous regulation likely requires longer interventions, opportunities for meaningful choice, and instructional designs that strengthen students' self-regulated learning skills.

Beyond the specific gains in controlled regulation, the intervention can also be interpreted as a media literacy exercise, helping students develop the ability to engage critically and autonomously with digital environments that they will encounter throughout their lifelong learning journey (Danov, 2024). Future research should adopt longitudinal approaches to determine whether externally driven behaviors can gradually transform into more autonomous forms of regulation, particularly during key academic transitions such as the first year of university.

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Abbreviations

The following abbreviations are used in this manuscript:

SDT	Self-Determination Theory
SRQ-L	Self-Regulation of Learning Questionnaire
AR	Autonomous Regulation
CR	Controlled Regulation
RAI	Relative Autonomy Index

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