Received: 3 August 2023 | Revised: 2 November 2023 | Accepted: 6 November 2023

DOI: 10.1002/ase.2358

RESEARCH REPORT

Anatomical Sciences Education WILEY

The combined effects of an anatomy program integrating drawing and gamification on basic psychological needs satisfaction among sport sciences students: Results of a natural experiment

Lorena Latre-Navarro[1] | Alejandro Quintas-Hijós[2] | María-José Sáez-Bondía[3]

[1]Department of Human Anatomy and Histology, Faculty of Health and Sport Sciences, University of Zaragoza, Huesca, Spain

[2]Department of Education Sciences, Faculty of Human Sciences and Education, University of Zaragoza, Huesca, Spain

[3]Department of Specific Didactics, Faculty of Education, University of Zaragoza, Zaragoza, Spain

Correspondence
Alejandro Quintas-Hijós, Department of Education Sciences, Faculty of Human Sciences and Education, University of Zaragoza, Huesca, Spain.
Email: quintas@unizar.es

Funding information
Dirección General de Ciencia e Investigación, Departamento de Educación, Ciencia y Universidades, Gobierno de Aragón, Grant/Award Number: S27_23R; Education, Audiovisual and Culture Executive Agency, Grant/Award Number: REL.I/2022-012

Abstract

According to self-determination theory, the need for competence, autonomy, and relatedness has been associated with intrinsic motivation. Fulfilling basic psychological needs can lead to better learning, academic performance, and well-being. In this study, an anatomy program integrated gamification and drawing methods to explore their influence on basic psychological needs satisfaction and potential learning implications. Basic psychological needs outcomes of sport sciences students were compared to test the effects of the Observe–Reflect–Draw–Edit–Repeat (ORDER) method and gamification (experimental condition) versus a non-ORDER and non-gamified program (control condition). These two different 30-h (7-week) anatomy education programs were implemented at two Spanish public universities with 116 first-year sport sciences students. Pre and post-treatment measurements were collected using the Basic Psychological Needs Satisfaction Scale. Statistical analyses included independent samples *t*-tests, ANCOVAs, and factorial repeated measures ANOVAs 2×2 (time×treatment). The gamified ORDER program achieved higher satisfaction scores in basic psychological needs compared to the control group ($t=2.98$, $p=0.004$, $d=0.54$). Additionally, an interaction effect between time and treatment was observed ($p=0.042$, $\eta_p^2=0.038$). Treatment and interaction effects were observed for 'autonomy' ($p=0.003$, $\eta_p^2=0.074$) and 'competence' satisfaction ($p=0.048$, $\eta_p^2=0.035$). A time effect was found for 'relatedness' in the control group, but no significant treatment or interaction effects were identified. The causes of these effects are debated in the study, as well as the limitations. These findings support the notion that students' basic psychological needs are better satisfied in anatomy education with the implementation of this multimethod educational intervention based on ORDER and gamification.

KEYWORDS
anatomy education, anatomy learning, evidence-based education, human anatomy teaching, perceived autonomy, perceived competence, self-determination theory

INTRODUCTION

Over the years, the field of anatomy has often been regarded as intricate and unvarying (Guimarães et al., 2017; Singh et al., 2019), with cadaveric dissection being the predominant method employed in the instruction of human anatomy (Taylor et al., 2022). However, recent reviews suggest that alternative educational methods may provide greater benefits for non-surgical professions, underscoring the imperative for research to assess the appropriateness of these innovative teaching methods (Estai & Bunt, 2016; Abu Bakar

et al., 2022). The necessity for further investigations is compounded by the limited availability of research studies focused on non-medical academic disciplines, such as sport sciences (Baños et al., 2022).

Active learning

Active learning methods and image-based exercises have demonstrated promising outcomes when compared to text-based exercises, highlighting their potential benefits for anatomy learning (Gross et al., 2017). Incorporating drawing into anatomy education has received praise from medical students (Greene, 2018) and enhances academic performance, especially when integrated into the ORDER method (Observe–Reflect–Draw–Edit–Repeat) within an interactive online tutorial for macroscopic anatomy (Backhouse et al., 2017). ORDER's cyclical method is based on cognitivist and constructivist learning theories, as well as critical observation, reflection, and drawing. In a recent review by Amin (2020), the importance of visualization in acquiring anatomical knowledge was highlighted and drawing was suggested as a strategic learning tool. The combination of haptics, observation, and drawing is thought to enhance comprehension (Naug et al., 2016) and form a more detailed mental representation of the content under study (Reid et al., 2019). The strategic combination of learning strategies could indeed serve as a powerful scaffold for didactic transposition (i.e., the transformation of a body of scientific knowledge from the moment it is produced until the point at which it is taught in the desired andragogical format). Consequently, this combination of learning strategies, particularly the integration of observation, and drawing, could assist students in visualizing and internalizing complex anatomical structures, thereby promoting deeper understanding. One of the greatest challenges in teaching anatomy is that there is no gap in the didactic transposition process (Chevallard, 1998; Pellón Arcaya et al., 2009), that is, the passage from "wise knowledge" (i.e., the comprehensive understanding of anatomical concepts possessed by experts or experienced anatomists) to "taught knowledge" (i.e., the knowledge as it is conveyed to and understood by students or learners). "Wise knowledge" might involve the intricate understanding of anatomical structures, their functions, and clinical applications, often held by experienced medical professionals. However, the challenge lies in effectively transmitting this depth of knowledge to students in an accessible and andragogically effective manner during anatomy education. For instance, a cardiologist's knowledge of the human heart is different (and more accurate) from the knowledge a student gains when viewing a schematic model of the heart on a blackboard. In this case, didactic clarity is achieved, but concreteness is diminished.

Using gamification to operationalize the self-determination theory

Self-determination Theory (SDT) is a macrotheory of human motivation and personality that has been extensively examined in university educational contexts (Ryan & Deci, 2000b), including studies on anatomy teaching and learning (Delgado et al., 2022; Tan et al., 2023). Specifically, the Basic Psychological Needs Theory is a branch of SDT that identifies three innate needs or optimal motivation and learning (Deci & Ryan, 2000): competence, autonomy, and relatedness. The fulfillment of these basic psychological needs is considered vital for personal development in learning. Experts in related disciplines, such as teaching physiology, have recommended investigating and enhancing these basic psychological needs among health science students (Lujan & DiCarlo, 2017). When students experience a sense of volition and psychological freedom (autonomy), a feeling of effectiveness and mastery (competence), and a sense of intimacy and connection with significant others (relatedness), their psychological well-being and overall health are likely to improve (Van der Kaap-Deeder et al., 2020; Delgado et al., 2022; Tan et al., 2023). In the context of learning, these factors play a crucial role as well. When learners have autonomy in their learning process, feel competent in their abilities, and have positive relationships with others, their learning outcomes, motivation, and overall educational experience are enhanced (Kusurkar et al., 2011). By extension, creating and applying a program to teach anatomy based on SDT theory is likely to improve learners' three basic psychological needs, which could indirectly affect their quality of learning (Ryan & Deci, 2017).

One way to operationalize SDT in education, which has already been studied, is by using the gamification method (Luarn et al., 2023). This method involves incorporating video game design elements into non-game contexts to influence students' behaviors and attitudes by targeting their motivation. The gamification method has shown potential in enhancing learning, engagement, and cooperation in medical education, while also facilitating the promotion of quick feedback (Krishnamurthy et al., 2022). In this approach, providing effective and timely feedback is of utmost importance (Hattie & Timperley, 2007; Hattie & Clarke, 2018). Gamified classroom platforms like ClassDojo (ClassDojo Inc, San Francisco, California) or Classcraft (Classcraft Studios Inc, Sherbrooke, Canada) serve as valuable tools, fostering collaboration, streamlining communication, and enabling both teachers and learners to monitor and incentivize positive learning behaviors while also facilitating the creation of digital portfolios. By combining gamification with high-quality feedback, ClassDojo creates an interactive and motivating learning environment that promotes student growth and performance, as demonstrated by the study conducted by Pratista (2023) on language learning among students 17 to 23 years of age. Furthermore, feedback provided through quiz games, such as Kahoot (Kahoot! AS, Oslo, Norway) or Quizizz (Quizizz Inc, Bangalore, India), plays a pivotal role in motivating and guiding students, offering valuable insights into their progress, and helping identify areas for improvement (Ismail et al., 2019). These gamified audience response systems have been found to significantly improve academic performance, satisfaction, engagement, and motivation to participate in the classroom compared to non-gamified systems (López-Jiménez et al., 2021). Therefore, it seems possible to improve the basic psychological needs addressed by SDT through gamification.

Study rationale and purpose

General interest among educators in adopting new evidence-based teaching methods has prompted a growing focus on exploring andragogical alternatives that enhance and complement anatomy teaching (Brunk et al., 2017; Memon, 2018; Kumar & Singh, 2020; Manzanares-Céspedes et al., 2021). Building upon recommendations for additional research and the principles provided by Evans and Pawlina (2022), which include the development of educational programs that foster active and effective learning, this study designed a multimodal anatomy education program for first-year sport sciences students. While no single instructional method has demonstrated substantial superiority in teaching anatomy (Abu Bakar et al., 2022), the implementation of multimodal teaching methods is known to yield higher student satisfaction (Bergman et al., 2013), increase student engagement (Diaz & Woolley, 2015), and result in positive student feedback (Anderton et al., 2016). As such, this study's multimodal program incorporated drawing exercises, reflection, collaborative teamwork, and gamification. Engaging students in drawing exercises and integrated gamified elements was intended to improve learners' psychological needs satisfaction and, thus, contribute to their well-being and learning potential (Ryan & Deci, 2017).

This study examined the influence of ORDER (Observe–Reflect–Draw–Edit–Repeat) and gamification on anatomy students' satisfaction as measured through the Basic Psychological Needs Satisfaction (BPNS) scale. The intention was to design a study that would overcome the limitations of previous empirical anatomy education and gamification research, such as the lack of comparative groups (Hanus & Fox, 2015; Ismail et al., 2019), single institution studies (Haspel et al., 2014; Neureiter et al., 2020), and/or the use of instruments/measures with little to no validity evidence (Bareither et al., 2013; Boylan et al., 2020). To negate concerns raised about the use of non-validated and/or low-quality instruments in anatomy instruction research (Curlewis et al., 2021), this work employed a well-vetted psychological scale with documented validity evidence. This study analyzed the effects of an anatomy education program using ORDER and gamification compared to a non-ORDER and non-gamified program among undergraduate sport sciences students. The following hypotheses (H) guided this work. The gamified ORDER anatomy intervention will produce more (H1) basic psychological needs satisfaction, (H2) autonomy satisfaction, (H3) competence satisfaction, and (H4) relatedness satisfaction in students than the non-ORDER and non-gamified intervention.

METHODS

Research design

A natural experiment with a non-randomized controlled design was conducted, using pre- and post-measures, and involved both an experimental and a control group. This design allowed for maximum control without losing the naturalness of the anatomy education activities. This research design has been successfully applied in a previous anatomy teaching study focused on serious games (Tan et al., 2023). The study received ethical approval from the Ethical Committee of Clinical Research of Aragon in Spain (statement number: PI22/383).

A 30-h educational program was designed and implemented utilizing the ORDER method and gamification for the experimental group. Meanwhile, the control group received a 30-h conventional program of anatomy classes inclusive of didactics and a laboratory experience. Each anatomy experience was conducted over 7 weeks as part of the curriculum for human anatomy classes at each institution and included both theoretical and practical sessions. The experimental and control experiences were administered by a different teacher at each institution. A pre-intervention BPNS measurement was taken in September 2022, followed by a post-intervention measurement seven weeks later in November 2022.

Participant eligibility criteria

Sport sciences students from two Spanish public universities were invited to participate in this study. The University of Zaragoza is situated in Aragon and the University of Lleida is in Catalonia, two different Autonomous Communities of Spain. Both universities offer a Bachelor's Degree in Physical Activity and Sport Sciences, and human anatomy is a first-year curriculum requirement for this degree. Students pursuing other degrees or those who did not complete both pre and post measurements, joined the experiment after it started, or dropped out of the course midway through the experiment were excluded.

Didactic design and applied educational programs

The experimental treatment consisted of an educational program based on the ORDER method (at a cognitive-comprehensive level) and gamification (at a motivational-affective level) and is represented in the Figure 1. The ORDER (Observe–Reflect–Draw–Edit–Repeat) method, initially described by Backhouse et al. (2017), was adapted as follows: (1) Observation, utilizing visual elements to present a problem; (2) reflection, facilitated through questioning; (3) drawing, encouraging individual representation of anatomical processes (Figure 2); (4) editing, fostering collaborative creation of a group drawing and making corrections; (5) repetition, reinforcing learning by revisiting the drawing with corrections at home and utilizing an interactive questionnaire using Quizizz in class. For gamification, the Mechanical-Dynamic-Aesthetic (Hunicke et al., 2004) architecture was utilized, and it was operationalized with the use of the educative application ClassDojo (Figure 3), as well as the response system and quiz-game application Quizizz. The teacher awarded virtual points using ClassDojo during anatomy classes, both in didactic and practical/laboratory sessions. Pre-designed point categories were added to the ClassDojo application including: Attention and Focus,

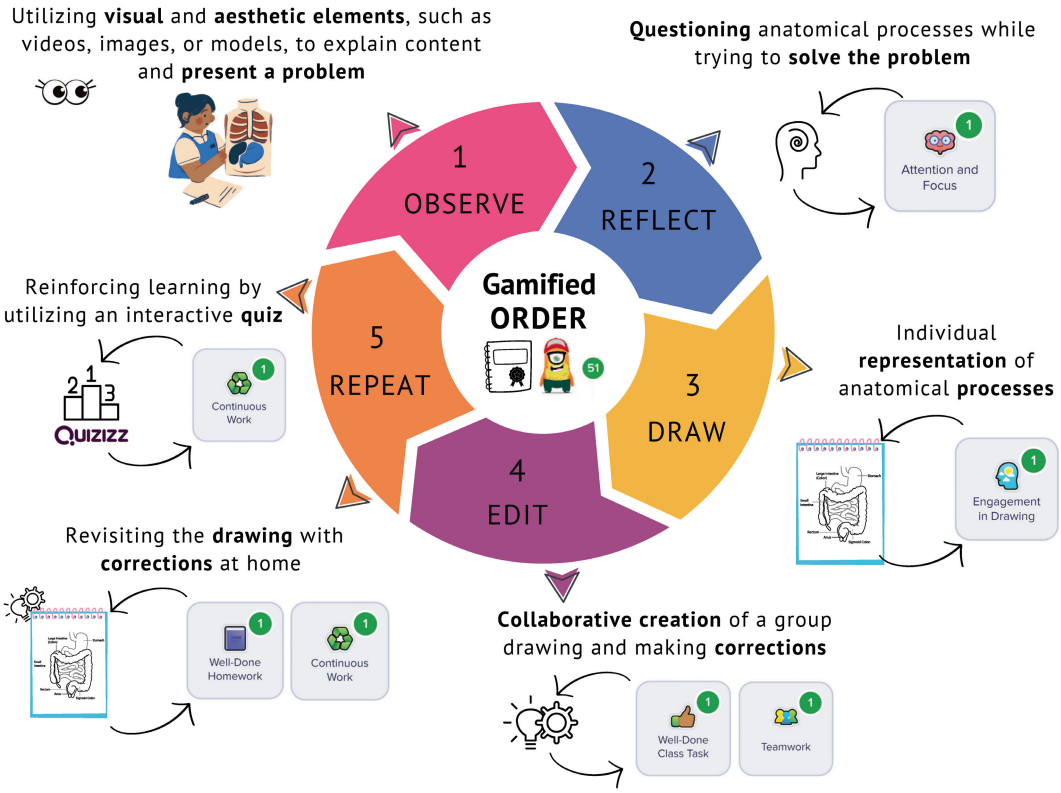

FIGURE 1 Gamified ORDER method in anatomy teaching used in the experimental treatment. *Source*: Authors' own elaboration using Canva and ClassDojo images, 2023.

FIGURE 2 Students drawing in their notebooks the anatomy of the digestive system and the processes that occur in it, as a phase of the ORDER method. *Source*: Authors' own elaboration, 2023.

Continuous Work, Engagement in Drawing, Teamwork, Well-Done Class Task, and Well-Done Homework (Figure 1). These categories were designed to enhance perceived autonomy, competence, and sociability and were based on the principles of educational feedback (Hattie & Timperley, 2007; Hattie & Clarke, 2018).

The control treatment consisted of classic didactic anatomy lectures and the use of common anatomy resources including digital and physical atlases, as well as the tracing or copying of drawings, along with the practice of note development. Note development, in this context, refers to the creation of annotations on traced drawings,

FIGURE 3 Example of a ClassDojo class overview. *Source*: Authors' own elaboration using ClassDojo, 2023.

such as indicating the reliefs and parts of a bone once its silhouette has been traced. It is important to note that the drawings were tracings and were not produced following the ORDER sequence or a reflective representation of processes. Gamification was not implemented in the control treatment. The control treatment aimed to represent conventional anatomy teaching.

In the curricula at both universities for the Bachelor's Degree in Physical Activity and Sport Sciences, human anatomy in relation to physical activity and sport is studied in the first semester of the first year. In both treatments, general anatomy, anatomical position, axes, and planes were taught. However, due to logistical and curricular reasons, there were also different contents covered. The experimental treatment was based on human body systems and organs (i.e., circulatory, respiratory, digestive, excretory, reproductive, endocrine, and nervous systems) and the control treatment only focused on the musculoskeletal system.

Measures

The participants completed 12 items from the Spanish version of the Basic Psychological Need Scale (Chen et al., 2015), which has demonstrated acceptable validity evidence for university students in the Spanish context (Cardella et al., 2020) as well as in other contexts and countries (Deci & Ryan, 2000; Gagné, 2003). This scale measures three dimensions: Autonomy, Competence, and Relatedness. Participants rated each item on a 5-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree). Specifically, they responded to four items each for the Basic Psychological Needs Satisfaction (Cronbach's $\alpha = 0.845$, McDonald's $\Omega = 0.846$): Autonomy Satisfaction Need ($\alpha = 0.754$, $\Omega = 0.772$), Competence Satisfaction Need ($\alpha = 0.812, \Omega = 0.813$), and Relatedness Satisfaction Need ($\alpha = 0.705$, $\Omega = 0.726$) variables. Appropriate values of internal consistency have been considered those found between 0.7 and 0.9 for both the alpha and omega index (Streiner, 2003; Hayes & Coutts, 2020).

Various variables were initially considered as potential covariates that could interfere with the dependent variables. The following variables were examined: sex, prior academic performance, university access, preference for drawing, study preference between images or text, previous anatomy studies, past learning experiences through drawing (excluding artistic instruction), perceived drawing competence, and habit of studying through drawings. These covariates were collected through a questionnaire administered at the beginning of the study to all participants. This questionnaire was administered at the same time as the BPNS scale (Supplemental Digital Appendix S1).

Statistical analyses

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 (BPNS, ANS, CNS, and RNS scores). An outlier was defined as any observation outside the range $[Q1 - k(Q3 - Q1), Q3 + k(Q3 - Q1)]$. Outliers were identified using the Tukey (1977) method, based on the interquartile range. Extreme outliers ($k = 3$) were eliminated. Slight outliers ($k = 1$) were also eliminated after verifying that they were not due to a data transcription error. The final data analysis was performed for each variable after excluding outliers.

Baseline differences between groups were compared across each variable using Student's *t*-tests for independent samples. After the intervention, a Studentss *t*-test for independent samples, and one-way ANCOVAs (controlling for covariates that were statistically significant and the pre-measure of variables) were applied. The

effect size was calculated using Cohen's *d*, and it was interpreted following Cohen's (1988) effect size classifications for small ($d=0.2$), medium ($d=0.5$), and large ($d\geq 0.8$) effects.

In the study, the two groups were compared using a factorial repeated measures ANOVA 2×2, which includes two factors: time (pre-treatment condition vs. post-treatment condition) and treatment (conventional anatomy teaching vs. gamified ORDER anatomy teaching). This statistical analysis allows for a comprehensive examination of the effects of both time and treatment on the study variables. The size effect was calculated by partial eta-squared (η_p^2) and it was interpreted following Cohen's (1988) effect size classifications for small ($\eta_p^2\geq 0.01$), medium ($\eta_p^2\geq 0.06$) and large ($\eta_p^2\geq 0.14$) effects. The analysis threshold (α) was set at ≤0.05. All statistical analyses were performed using IBM SPSS Statistics (version 26.0).

RESULTS

Participants

A total of 205 first-year sport sciences students from two Spanish public universities were invited to participate in this study (University of Zaragoza, $n=81$ and University of Lleida, $n=124$). Among these 205 students, a total of 116 completed the study with pre and post measurements. Sixty students were from the University of Zaragoza ($n=12$ women; $n=46$ men) and 56 from the University of Lleida ($n=13$ women; $n=43$ men). Students not meeting the eligibility criteria were excluded ($n=89$). The mean age of the 116 included participants was 19.00 (SD = 1.96). The mean age of participants from the University of Zaragoza (18.65, SD = 1.25) was comparable to that of participants from the University of Lleida (19.38, SD = 2.47).

Contextual outcomes

Descriptive statistics, including means and standard deviations for each treatment and variable are presented in Table 1. No significant baseline differences were found between the two groups for each of the studied dependent variables: BPNS ($p=0.401$), ANS ($p=0.819$), CNS ($p=0.234$), and RNS ($p=0.859$).

Only four of the investigated covariates were found to be significant and were considered in the ANCOVA analysis: study preference between images or text ($p=0.005$), prior academic performance ($p=0.002$), previous learning experiences through drawing (excluding artistic instruction) ($p=0.007$), and habit of studying through drawings ($p=0.028$).

Basic psychological needs satisfaction (BPNS)

A post-intervention *t*-test for independent samples revealed higher BPNS scores in the experimental group compared to the control group ($t(110)=2.98$, $p=0.004$; MD = 3.24 [95% CI, 1.08–5.39]), with a medium effect size ($d=0.54$). An ANCOVA, controlling all statistically significant covariates and the pre-measurement (the BPNS pretest score), revealed a higher BPNS in the experimental treatment than control treatment ($F(1)=5.56$, $p=0.02$; MD = 2.54 [95% CI, 0.404–4.671]), with a small effect size ($\eta_p^2=0.05$, $R=36.1\%$).

A factorial repeated measures ANOVA 2×2 (time×treatment) showed an interaction effect on BPNS ($F(1)=4.22$, $p=0.042$) with a small effect size ($\eta_p^2=0.038$). This indicates the change in BPNS scores between the pre- and post-treatment phases for the experimental and control groups occurred at different magnitudes when accounting for time. Therefore, it can be concluded that there is an effect of the treatment, even though a primary effect has not been explicitly described (Garrido García, 2008). As such, H1 was supported whereby the gamified ORDER anatomy intervention generated higher levels of BPN satisfaction in students compared to the non-ORDER and non-gamified intervention.

Autonomy Need Satisfaction (ANS)

A post-intervention *t*-test for independent samples revealed a higher ANS in the experimental group than the control group ($t(114)=3.62$, $p=0.000$; MD = 1.62 [95% CI, 0.78–2.66]), with a medium effect size ($d=0.64$). An ANCOVA, controlling all statistically significant covariates and the pre-measurement (the ANS pretest score), revealed a higher ANS in the experimental group than the control group ($F(1)=8.048$, $p=0.005$; MD = 1.44 [95% CI, 0.435–2.453]) with a medium effect size ($\eta_p^2=0.069$, $R=25.2\%$).

A factorial repeated-measures ANOVA 2×2 (time×treatment) showed an interaction effect on ANS ($F(1)=9.145$, $p=0.003$) with a medium effect size ($\eta_p^2=0.074$), and a treatment effect ($F(1)=5.00$,

TABLE 1 Descriptive statistics: Comparison of basic psychological needs satisfaction between control and experimental treatments.

	Control treatment		Experimental treatment	
	Baseline	Follow-up	Baseline	Follow-up
Basic psychological needs satisfaction	49.16 ± 5.32 (53)	47.49 ± 5.34 (53)	50.07 ± 5.89 (59)	50.42 ± 5.75 (59)
Autonomy need satisfaction	15.29 ± 2.72 (56)	14.38 ± 2.85 (56)	15.41 ± 2.73 (60)	16.10 ± 2.27 (60)
Competence need satisfaction	16.74 ± 2.39 (53)	16.21 ± 2.20 (53)	17.09 ± 2.44 (59)	17.29 ± 2.19 (59)
Relatedness need satisfaction	17.30 ± 2.34 (53)	16.60 ± 2.19 (53)	17.30 ± 2.56 (60)	17.22 ± 2.41 (60)

Note: Data are presented as mean ± standard deviation (number of participants after eliminating outliers).

$p=0.027$), higher in the experimental group (MD=0.928 [95% CI, 0.106–1.75]), with a small effect size ($\eta_p^2=0.042$). Thus, H2 was supported whereby the gamified ORDER anatomy intervention produced more ANS in students than the non-ORDER and non-gamified intervention.

Competence need satisfaction (CNS)

A post-intervention *t*-test for independent samples revealed a higher CNS in the experimental group than the control group ($t(110)=2.604$, $p=0.011$; MD=1.08 [95% CI, 0.26–1.9]), with a small effect size ($d=0.39$). An ANCOVA, controlling all statistically significant covariates and the pre-measurement (the CNS pretest score), revealed a higher CNS in the experimental group compared to control ($F(1)=4.682$, $p=0.033$; MD=1.06 [95% CI, 0.089–2.028]) with a small effect size ($\eta_p^2=0.041$, $R=28.7\%$).

A factorial repeated-measures ANOVA 2×2 (time×treatment) showed an interaction effect on CNS ($F(1)=4.012$, $p=0.048$) with a small effect size ($\eta_p^2=0.035$), and a treatment effect ($F(1)=5.27$, $p=0.024$), higher in the experimental group (MD=0.868 [95% CI, 0.119–1.618]), with a small effect size ($\eta_p^2=0.045$). Thus, H3 was supported whereby the gamified ORDER anatomy intervention produced more CNS in students than the non-ORDER and non-gamified intervention.

Relatedness need satisfaction (RNS)

A post-intervention *t*-test for independent samples revealed a higher RNS in the experimental treatment than control treatment ($t(111)=3.63$, $p=0.000$; MD=1.36 [95% CI, 0.41–2.31]), with a medium effect size ($d=0.64$). An ANCOVA, controlling all statistically significant covariates and the pre-measurement (the RNS pretest score), revealed a higher RNS in the experimental group compared to control ($F(1)=4.16$, $p=0.044$; MD=1.076 [95% CI, 0.031–2.121]), with a small effect size ($\eta_p^2=0.037$, $R=21.1\%$).

A factorial repeated-measures ANOVA 2×2 (time×treatment) revealed a significant time effect on RNS ($F(1)=4.813$, $p=0.030$; MD=0.575 [95% CI, 0.055–4.094]), with a small effect size ($\eta_p^2=0.043$). Specifically, the RNS variable significantly decreased in the control group ($F(1)=8.685$, $p=0.005$; MD=1.038 [95% CI, 0.330–1.746]), showing a large effect size ($\eta_p^2=0.153$), while the RNS variable remained stable in the experimental group ($p=0.759$). Although the difference in the RNS variable between groups at baseline was not significant and the difference between groups in the post-measurement was significant, the absence of a significant interaction suggests the lack of a treatment effect (Garrido García, 2008). Therefore, H4 was not supported. Despite the noticeable differences in post-measurements between the groups, it cannot be concluded that this difference in the RNS variable was due to the intervention, as no significant interaction or treatment effect was found. However, it is worth noting that a significant time effect was observed in the control treatment. This time effect could suggest that factors other than the intervention itself, such as natural progression, external influences, or specific factors unique to the control group, might have influenced the observed changes in the RNS variable.

DISCUSSION

This study sought to determine whether the integration of ORDER and gamification in a human anatomy education curriculum could lead to greater basic psychological needs satisfaction, specifically related to autonomy, competence, and relatedness among sport sciences students, compared to a conventional anatomy curriculum in a similar academic context.

Basic psychological needs satisfaction

The findings demonstrate that the combination of ORDER and gamification results in a significantly higher level of students' BPN satisfaction, which plays a pivotal role in the learning process. These findings provide support for the idea that students' basic psychological needs are better satisfied in learning environments that implement multimethod approaches, such as ORDER and gamification. This aligns with previous studies that have described multimodal teaching methods (constructive, collaborative, contextual, and self-directed) as being perceived with higher satisfaction by students when compared to conventional methods for surface anatomy teaching (Bergman et al., 2013). The success of this intervention could be attributed to the gamification program, which has been previously associated with increasing student interactivity (Bouchrika et al., 2021) and enhancing user engagement by mediating the satisfaction of basic psychological needs (autonomy, competence, and relatedness) between game dynamics and enjoyment (Suh et al., 2018). The need for competence, autonomy, and relatedness has been described as influencing enjoyment and ultimately leading to intrinsic motivation (Suh et al., 2018). Intrinsic motivation has been associated with improved learning, enhanced conceptual understanding, higher academic performance, and achievement, as well as increased levels of well-being (Ten Cate et al., 2011). Moreover, gamification has been linked to intrinsic motivation (Suh et al., 2018), suggesting that this method could enhance students' performance in anatomy (Abdel Meguid et al., 2020), as well as the ORDER method (Backhouse et al., 2017). The current research utilized two methods to provide cognitive-comprehensive advantages (via ORDER) and to offer motivational-affective advantages for basic psychological needs (via gamification). The present study showed that the combination of ORDER and gamification is effective, even after considering significant covariates such as students' drawing preferences and previous experiences. This reinforces the results of Backhouse et al. (2017) who concluded that learning performance

using an art learning method was independent of students' visual learning preferences and art background.

Autonomy need satisfaction

The intervention incorporating ORDER and gamification had a significant influence on ANS, surpassing the satisfaction levels achieved by the control group. The introduction of a rewards system and the self-expression activities in the experimental treatment may partially explain why students reported heightened ANS, as rewards and self-expression have been shown to enhance ANS (Suh et al., 2018). The provision of positive reinforcements, such as ClassDojo points for consistently engaging in autonomous work, is likely to have fostered increased motivation and a sense of empowerment among students during their learning experience. Earning rewards for autonomous efforts may have enhanced students' autonomy perceptions and self-control over their individual learning processes. Rewards, in terms of obtaining points as informative feedback (rather than using them to control behavior), are known to improve ANS (Deci et al., 1999).

Students are autonomous when they participate voluntarily and reflect. That is, when there is a suitable environment for the exchange of viewpoints, students feel they have a voice and, thus, feel engaged and empowered to take part in the exchange of ideas (Lujan & DiCarlo, 2017). In the gamified ORDER experimental treatment, students had the freedom to create their own drawings, not being allowed to trace or copy from existing diagrams. Moreover, as the educational program progressed, students became more familiar with the ORDER sequence, which enabled them to engage in autonomous work in their notebooks. Anecdotally, these students willingly responded to the teacher's questions in class during gamified sessions with point-based rewards, and this may have influenced their ANS. The experimental group was also able to work on self-expression through the customization of ClassDojo avatars, which were "monsters" (Figure 3). According to Ma and Agarwal (2007), a person's avatar can serve as a focal point for expressing their own style and personality which can lead to greater autonomy (Suh, 2015; Suh et al., 2018). These strategies of self-expression may have influenced the increase of ANS, as previously demonstrated in the literature (Suh et al., 2018).

Furthermore, some experts (Lujan & DiCarlo, 2017) recommend a multisensory approach to teaching so that students can feel more self-fulfilled using models, demonstrations, discussions, debates, collaborative learning, questions, games, and cooperation. All these strategies were employed in different phases of the gamified ORDER process in the experimental treatment, which could also partially justify why autonomy was higher for the experimental group.

Competence need satisfaction

In addition to these variables, the experimental treatment also showed higher CNS scores. This finding may be partially attributed to factors such as task repetition, reward systems, quiz-games, and competition. Nevertheless, it is essential to note that task repetition alone is not sufficient for effective learning. Effective feedback is necessary to facilitate productive learning (Hattie & Timperley, 2007; Hattie & Clarke, 2018). The implemented gamification program provided feedback by utilizing reward systems, using ClassDojo points as reinforcement in class tasks, and incorporating classroom response systems and interactive quizzes with Quizizz at the conclusion of teaching-learning sequences. However, although gamification is not solely focused on "rewards" and should be viewed in the context of self-expression, competition (e.g., through competitive work), and altruism (e.g., through cooperative work), it is noteworthy that rewards do enhance self-worth and positively influence competence satisfaction (Suh et al., 2018).

Competition also contributes to CNS as it encourages individuals to challenge each other to achieve the best possible results (Suh et al., 2018). Obtaining rewards results in a repeated sense of accomplishment thereby enhancing self-worth and CNS (Przybylski et al., 2010). Furthermore, individuals derive satisfaction from comparing their performance with others, and the leaderboard during quiz-games or discussing ClassDojo scores among classmates plays a significant role in celebrating the winners. This competitive environment motivates individuals to strive for higher performance (Ryan & Deci, 2000a; Suh et al., 2018). Bartle's, 2003 study suggests that in ludic contexts, competitiveness may be particularly appealing to the "killer" student profile, characterized by hypercompetitiveness. However, the majority of students typically fall into profiles such as "explorers", "achievers", or "socializers". Therefore, a gamified system can and should introduce regulated competition systems, along with a self-critical and self-referential approach to progress. On the other hand, another study found that if the game is too difficult for players to achieve, they are likely to feel frustrated during play, but this frustration does not significantly influence their willingness to continue playing (Chumbley & Griffiths, 2006). Consequently, during the experimental intervention, it was important to ensure that the rewards in the classroom were attainable, and that the difficulty level was progressively adjusted to each stage of the learning process.

The experimental treatment, which showed higher levels of CNS, integrated techniques such as drawing and quizzes that have previously been shown to enhance perceived self-confidence, engagement, and deep learning in students, along with other techniques (Nicholson et al., 2016). Notably, observation and drawing have been found to significantly enhance the competence of anatomy students, enabling them to recall memorized images and redraw them on paper in the absence of the object, and to identify inaccuracies when compared to illustrations from an anatomy atlas (Reid et al., 2019). The inclusion of gamification using response systems and quiz-games in the experimental treatment may have contributed to the observed effect of higher CNS, as previous studies have found that these resources increase satisfaction, engagement, and motivation to participate in the classroom when exposed to gamified learning experiences (López-Jiménez

et al., 2021). Moreover, quiz-games have shown positive effects on achievement and engagement both in class and as a revision tool prior to assessment in higher education teaching of the anatomical sciences (Wilkinson, 2017). They also serve to motivate students to study while helping them identify content areas that require reinforcement and fostering awareness of their learning progress (Ismail et al., 2019; Côrtes et al., 2022; Cortés-Pérez et al., 2023). Furthermore, student participation in these quiz-games has been found to be a predictor of their academic performance (Alexander et al., 2009; Garza et al., 2023).

Relatedness need satisfaction

In this study, a decline in RNS was observed in the control group over time (time effect), while this variable remained stable in the experimental group. It suggests that, without any specific intervention or treatment, relatedness satisfaction tends to decrease as time goes on. Differences in RNS scores were found between the post-measurements of the experimental and control groups, with higher scores in the experimental group. One possible interpretation is that the experimental treatment might be playing a role in preventing or slowing down this decline, thus acting as a protective factor to help maintain relatedness satisfaction. However, the repeated measures factorial analysis did not reveal any interaction effect between time and treatment, nor any treatment effect, suggesting that the experimental treatment does not significantly act as a protective factor. Hence, alternative explanations for this decline in relatedness satisfaction over time in the control group must be explored, which are independent of the treatment received. Such an effect could be partially explained by changes in classroom composition during the early weeks of instructions whereby enrollment changes often result in classroom composition instability; thus, affecting interactions and relations among peers. In this study, of the 124 control group participants, only 56 remained in the study from the pre-measurement until the post-measurement. In contrast, of the 81 experimental group participants at the other institution, 60 completed both the pre- and post-measurement requirements. Therefore, the stability of the classroom composition was higher in the experimental group, which could have led to more stability in relatedness.

The competition through the ClassDojo's rewards system and weekly quiz-games was expected to increase relatedness satisfaction, as competition fosters interactions among people (Suh et al., 2018) and students feel more heard through these types of activities (Laura de la Cruz et al., 2021).

Moreover, altruism, defined as the behavior of giving gifts to others, may also influence relatedness satisfaction and has been described as a strong motivator when individuals seek to enhance their interpersonal relationships (Suh et al., 2018). Although the educational program began on the first day of class when students were still unfamiliar with each other in both the control and experimental groups, it can be understood that this altruism was partially fostered in the experimental treatment. This treatment included cooperative work during the "Editing" phase of the drawings in the ORDER process, as well as the use of gamification through ClassDojo, which rewarded teamwork and fostered a positive classroom environment and collaboration among students (Pratista, 2023). This may also partially explain why RNS was maintained and did not decline over time in the experimental group, in contrast to the control group. Furthermore, students could react with "likes" and make comments both on their small group's ClassDojo stories (with photos) and on corrections of their individual or group assignments, interacting in a more personal way. Additionally, in ClassDojo, students were divided into teams, whose names they had chosen previously, which could generate a sense of belonging to the group. Interaction with these immersion-oriented elements could have promoted feelings of relatedness among students in the experimental group, as suggested by Bitrián et al. (2021).

There may be other factors that could have influenced the maintenance of RNS in the experimental group. Firstly, frequent encouragement of debates in the classes as part of the "Reflection" phase of the ORDER process likely played a role. Secondly, addressing each student by name whenever they participated in class, as was done in the experimental group during reward and feedback moments, has been associated with an improvement in this basic need. This improvement stems from the atmosphere of trust that is generated when students feel more valued, as instructors know their names (Cooper et al., 2017). Similarly, the same occurred with the quiz-games in the experimental treatment during the full-group sessions, as the names of students with the highest scores in the interactive quizzes were publicly recognized (while avoiding projecting the lowest scores to prevent possible negative feelings among students at the bottom of the ranking). On the other hand, in the control group, attendance was not monitored, and no gamification program was implemented. As a result, this ongoing situation of public recognition did not take place in the control group. However, as previously explained, definitive conclusions about this variable cannot be drawn, emphasizing the necessity for further research the effects of ORDER and gamification on RNS.

Limitations and future directions

Although combining ORDER (cognition–understanding) and gamification (motivation–emotion) is a sound educational approach, this combining of variables poses a methodological problem making it more challenging to determine the individual effects of each method. It is plausible that the substantial effects of one method could have masked or compensated for the lesser effects of the other method. Thus, one limitation of this study is the challenge to distinguish between the specific contributions of the ORDER method versus the gamification method in the educational intervention. While gamification has received more attention in previous studies, there is limited research on ORDER due to its novelty.

Consequently, future studies could consider investigating the effects of the ORDER approach and gamification, both in combination and separately. This would enable the differentiation of effects resulting from the combined approach versus those attributable to each method individually, contributing to a deeper understanding of how this multimodal method enhances its effectiveness. Furthermore, we recommend conducting additional combination testing with other methods to identify the most effective multimodal approaches.

To uphold ethical standards, uniform treatment was administered to all students from the same university. As a result, the research compared the experimental and control treatments within the same bachelor's degree program at two different public universities. This implied that each teacher followed the study plan and the sequence of content delivery specific to their respective institutions, as detailed in the methods section. Moreover, certain factors such as attendance monitoring and instructors providing notes were implemented in the experimental group but were absent in the control group. Furthermore, at each university, students underwent different evaluation tests, which could influence their approach to studying and preparing for the subject, potentially affecting the results of this study. We recommend that, in future research, if possible, these aspects should be standardized.

In our attempt to maintain the naturalness of the study, it was not feasible for the same instructor to teach classes at two different universities during the 7 weeks of the study. Therefore, the influence of the instructor, in this case, must be considered in conjunction with the effect of the treatment and is not separable. If one wishes to isolate and investigate the instructor's effect, a study would need to be conducted in a controlled experimental environment, which may compromise the study's natural setting.

To obtain reliable pre-measurements and accurately assess the treatment effect, the experiment was conducted at the beginning of the academic year. However, this led to notable experimental attrition due to high student enrollment changes in the early weeks. Replicating the study at a different time with fewer social changes and classroom variations could provide valuable insights. This method would help determine if there is no treatment effect in relatedness satisfaction and whether the results hold consistent across different contexts. Additionally, it is advisable to consider increasing the sample size in future studies to increase its generalizability.

Other potential lines of future research include investigating the factors contributing to the decline in relatedness satisfaction over time in the group with a conventional anatomy program, exploring whether the gamified ORDER treatment can prevent or mitigate this decline, potentially acting as a protective factor in maintaining this variable, especially when the treatment duration extends beyond 7 weeks. Additionally, it may be worthwhile to investigate whether the experimental treatment reaches a ceiling effect in competence and autonomy needs satisfaction.

CONCLUSIONS

The findings of this study indicate that a gamified-ORDER anatomy education program results in higher basic psychological needs satisfaction, specifically related to autonomy and competence, among sport sciences students compared to a non-ORDER and non-gamified educational program. Furthermore, it was observed that satisfaction of relatedness decreases over time in the control group. However, it is important to note that this difference cannot be definitively attributed to the intervention, as no interaction or treatment effect was detected. To further bolster the case for the efficacy of the gamified ORDER method in anatomy education, additional research and replication studies are warranted.

ACKNOWLEDGMENTS

The authors would like to extend their gratitude to both universities (University of Lleida and University of Zaragoza), teachers, and students for their valuable participation and cooperation in this study. Finally, Lorena Latre-Navarro wishes to acknowledge the support of the Doctoral School of the University of Zaragoza for enabling the development of this study as part of the Education Doctoral Program.

FUNDING INFORMATION

This research has been made possible through grant REL.I/2022-012 from the European Commission EACEA (Education, Audiovisual and Culture Executive Agency), and through grant S27_23R from the Government of Aragón (Directorate General of Science and Research, Department of Education, Science and Universities).

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no conflict of interest.

ETHICS STATEMENT

The study received the ethical approval the Ethical Committee of Clinical Research of Aragon (Spain) on September 7, 2022 (statement number: PI22/383).

ORCID

Lorena Latre-Navarro https://orcid.org/0000-0003-3948-333X
Alejandro Quintas-Hijós https://orcid.org/0000-0003-4621-6993
María-José Sáez-Bondía https://orcid.org/0000-0002-8733-1501

REFERENCES

Abdel Meguid EM, Smith CF, Meyer AJ. Examining the motivation of health profession students to study human anatomy. Anat Sci Educ. 2020;13(3):343–52.

Abu Bakar YI, Hassan A, Yusoff MSB, Kasim F, Abdul Manan Sulong H, Hadie SNH. A scoping review of effective teaching strategies in surface anatomy. Anat Sci Educ. 2022;15(1):166–77.

Alexander CJ, Crescini WM, Juskewitch JE, Lachman N, Pawlina W. Assessing the integration of audience response system technology in teaching of anatomical sciences. Anat Sci Educ. 2009;2(4):160–6.

Amin A. 'Drawing' to learn anatomy: exploring the theoretical underpinning and conditions favouring drawing based learning. J Pak Med Assoc. 2020;70(11):2017–22.
Anderton R, Chiu L, Aulfrey S. Student perceptions to teaching undergraduate anatomy in health sciences. Int J High Educ. 2016;5(3):201–16. Available from: https://researchonline.nd.edu.au/health_article/167
Backhouse M, Fitzpatrick M, Hutchinson J, Thandi CS, Keenan ID. Improvements in anatomy knowledge when utilizing a novel cyclical "observe-reflect-draw-edit-repeat" learning process. Anat Sci Educ. 2017;10(1):7–22. https://doi.org/10.1002/ase.1616
Bareither ML, Arbel V, Growe M, Muszczynski E, Rudd A, Marone JR. Clay modeling versus written modules as effective interventions in understanding human anatomy. Anat Sci Educ. 2013;6(3):170–6.
Bartle R. Designing virtual worlds. Berkeley, CA: New Riders; 2003.
Baños R, Morán-Navarro R, Toval A, del Lidón López-Iborra M, Morales-Delgado N, Ferrán JL. Aprendizaje y evaluación de contenidos de anatomía humana en Ciencias del Deporte mediante vídeos de Surf. Espiral Cuadernos del Profesorado. 2022;15(30):1–10. Available from: https://ojs.ual.es/ojs/index.php/ESPIRAL/article/view/5767
Bergman EM, Sieben JM, Smailbegovic I, de Bruin ABH, Scherpbier AJJA, van der Vleuten CPM. Constructive, collaborative, contextual, and self-directed learning in surface anatomy education. Anat Sci Educ. 2013;6(2):114–24. Available from: https://pubmed.ncbi.nlm.nih.gov/22899567/
Bitrián P, Buil I, Catalán S. Enhancing user engagement: the role of gamification in mobile apps. J Bus Res. 2021;132:170–85.
Bouchrika I, Harrati N, Wanick V, Wills G. Exploring the impact of gamification on student engagement and involvement with e-learning systems. Interact Learn Environ. 2021;29(8):1244–57.
Boylan PM, Sedlacek J, Santibañez M, Church AF, Lounsbury N, Nguyen J. Development and implementation of interprofessional relations between a college of pharmacy and osteopathic residency programs in a community teaching hospital. J Pharm Technol. 2020;36(1):3–9.
Brunk I, Schauber S, Georg W. Do they know too little? An inter-institutional study on the anatomical knowledge of upper-year medical students based on multiple choice questions of a progress test. Ann Anat. 2017;209:93–100. Available from: https://www.sciencedirect.com/science/article/pii/S094096021630156X
Cardella G, Hernández-Sánchez B, Sánchez-García J. Basic psychological needs as a motivational competence: examining validity and measurement invariance of Spanish BPNSF scale. Sustainability. 2020;12(13):5422. https://doi.org/10.3390/su12135422
Chen B, Vansteenkiste M, Beyers W, Boone L, Deci EL, Van der Kaap-Deeder J, et al. Basic psychological need satisfaction, need frustration, and need strength across four cultures. Motiv Emot. 2015;39:216–36.
Chevallard Y. La transposición didáctica. Del saber sabio al saber enseñado. Buenos Aires: Aique; 1998.
Chumbley J, Griffiths M. Affect and the computer game player: the effect of gender, personality, and game reinforcement structure on affective responses to computer game-play. Cyberpsychol Behav. 2006;9(3):308–16. https://doi.org/10.1089/cpb.2006.9.308
Cohen J. Statistical power analysis for the behavioral sciences. 2nd ed. New York: Routledge; 1988.
Cooper KM, Haney B, Krieg A, Brownell SE. What's in a name? The importance of students perceiving that an instructor knows their names in a high-enrollment biology classroom. CBE Life Sci Educ. 2017;16(1):ar8.
Côrtes MA, de Carvalho ED, Souza R, Valentim FC, Cerqueira GS, de Sousa Alves R. O Kahoot© como estratégia de aprendizagem no ensino de ciências morfofuncionais. Rev Cienc Méd Biol. 2022;21(2):267–73.
Cortés-Pérez I, Zagalaz-Anula N, López-Ruiz MD, Díaz-Fernández Á, Obrero-Gaitán E, Osuna-Pérez MC. Study based on gamification of tests through Kahoot!TM and reward game cards as an innovative tool in physiotherapy students: a preliminary study. Healthcare. 2023;11(4):578.
Curlewis K, Leung B, Perera M, Bazira PJ, Sanders KA. Clay-based modeling in the anatomist's toolkit: a systematic review. Anat Sci Educ. 2021;14(2):252–62. https://doi.org/10.1002/ase.1996
Deci EL, Koestner R, Ryan RM. A meta-analytic review of experiments examining the effects of extrinsic rewards on intrinsic motivation. Psychol Bull. 1999;125(6):627–68.
Deci EL, Ryan RM. The 'what' and 'why' of goal pursuits: human needs and the self-determination of behavior. Psychol Inq. 2000;11(4):227–68.
Delgado C, Fasce E, Ortiz L, Torres C, Neira C, Inostroza N. Motivation and satisfaction of medical students participating in an educational intervention on pathology. Rev Med Chil. 2022;150(10):1386–95.
Diaz CM, Woolley T. Engaging multidisciplinary first year students to learn anatomy via stimulating teaching and active, experiential learning approaches. Med Sci Educ. 2015;25(4):367–76.
Estai M, Bunt S. Best teaching practices in anatomy education: a critical review. Ann Anat. 2016;208:151–7. Available from: https://www.sciencedirect.com/science/article/pii/S0940960216300322
Evans DJR, Pawlina W. The future of anatomy education: learning from Covid-19 disruption. Anat Sci Educ. 2022;15(4):643–9.
Gagné M. The role of autonomy support and autonomy orientation in prosocial behavior engagement. Motiv Emot. 2003;27:199–223. https://doi.org/10.1023/A:1025007614869
Garrido García J. La interacción entre factores en el análisis de varianza: errores de interpretación [Doctoral Thesis]. Madrid: Universidad Autónoma de Madrid; 2008.
Garza M, Olivan S, Monleón E, Cisneros AI, García-Barrios A, Ochoa I, et al. Performance in Kahoot! Activities as predictive of exam performance. BMC Med Educ. 2023;23(1):413.
Greene SJ. The use and effectiveness of interactive progressive drawing in anatomy education. Anat Sci Educ. 2018;11(5):445–60. https://doi.org/10.1002/ase.1784
Gross MM, Wright MC, Anderson OS. Effects of image-based and text-based active learning exercises on student examination performance in a musculoskeletal anatomy course. Anat Sci Educ. 2017;10(5):444–55. https://doi.org/10.1002/ase.1684
Guimarães B, Dourado L, Tsisar S, Diniz JM, Madeira MD, Ferreira MA. Rethinking anatomy: how to overcome challenges of medical education's evolution. Acta Med Port. 2017 Feb 27;30(2):134–40. https://doi.org/10.20344/amp.8404
Hanus MD, Fox J. Assessing the effects of gamification in the classroom: a longitudinal study on intrinsic motivation, social comparison, satisfaction, effort, and academic performance. Comput Educ. 2015;80:152–61.
Haspel C, Motoike HK, Lenchner E. The implementation of clay modeling and rat dissection into the human anatomy and physiology curriculum of a large urban community college. Anat Sci Educ. 2014;7(1):38–46.
Hattie J, Clarke S. Visible learning: feedback. New York, NY: Routledge; 2018.
Hattie J, Timperley H. The power of feedback. Rev Educ Res. 2007;77(1):81–112.
Hayes AF, Coutts JJ. Use omega rather than Cronbach's alpha for estimating reliability. But…. Commun Methods Meas. 2020;14(1):1–24.
Hunicke R, LeBlanc M, Zubek R. MDA: a formal approach to game design and game research. Workshop on challenges in game AI; 2004 Game Developers Conference, San Jose 2001–2004. Available from: https://users.cs.northwestern.edu/~hunicke/MDA.pdf
Ismail MAA, Ahmad A, Mohammad JAM, Fakri NMRM, Nor MZM, Pa MNM. Using Kahoot! as a formative assessment tool in

medical education: a phenomenological study. BMC Med Educ. 2019;19(1):230.
Krishnamurthy K, Selvaraj N, Gupta P, Cyriac B, Dhurairaj P, Abdullah A, et al. Benefits of gamification in medical education. Clin Anat. 2022;35(6):795–807. https://doi.org/10.1002/ca.23916
Kumar R, Singh R. Model pedagogy of human anatomy in medical education. Surg Radiol Anat. 2020;42(3):355–65. https://doi.org/10.1007/s00276-019-02331-7
Kusurkar RA, Croiset G, Ten Cate OTJ. Twelve tips to stimulate intrinsic motivation in students through autonomy-supportive classroom teaching derived from self-determination theory. Med Teach. 2011;33(12):978–82.
Laura de la Cruz KM, Hinojosa Condori C, Condori Chacolli ME, Montesinos Valencia CC, Condori Peralta FL. Gamificando con Quizizz en la evaluación formativa de la enseñanza del inglés. La Investigación Científica y Académica Transdisciplinaria. Colombia: Editorial EIDEC; 2021. p. 261–77.
López-Jiménez JJ, Fernández-Alemán JL, García-Berná JA, González LL, Sequeros OG, Ros JN, et al. Effects of gamification on the benefits of student response systems in learning of human anatomy: three experimental studies. Int J Environ Res Public Health. 2021;18(24):13210. Available from: https://pubmed.ncbi.nlm.nih.gov/34948818/
Luarn P, Chen CC, Chiu YP. Enhancing intrinsic learning motivation through gamification: a self-determination theory perspective. Int J Inf Learn Tech. 2023;40:413–24.
Lujan HL, DiCarlo SE. A personal connection: promoting positive attitudes towards teaching and learning. Anat Sci Educ. 2017;10(5):503–7.
Ma M, Agarwal R. Through a glass darkly: information technology design, identity verification, and knowledge contribution in online communities. Inf Syst Res. 2007;18(1):42–67.
Manzanares-Céspedes MC, Dalmau-Pastor M, Simon de Blas C, Vázquez-Osorio MT. Body donation, teaching, and research in dissection rooms in Spain in times of Covid-19. Anat Sci Educ. 2021;14(5):562–71. https://doi.org/10.1002/ase.2093
Memon I. Cadaver dissection is obsolete in medical training! A misinterpreted notion. Med Princ Pract. 2018;27:201–10. https://doi.org/10.1159/000488320
Naug HL, Colson NJ, Donner D. Experiential learning, spatial visualization and metacognition: an exercise with the "blank page" technique for learning anatomy. Health Prof Educ. 2016;2(1):51–7.
Neureiter D, Klieser E, Neumayer B, Winkelmann P, Urbas R, Kiesslich T. Feasibility of Kahoot! as a real-time assessment tool in (histo-)pathology classroom teaching. Adv Med Educ Pract. 2020;11:695–705.
Nicholson LL, Reed D, Chan C. An interactive, multi-modal anatomy workshop improves academic performance in the health sciences: a cohort study. BMC Med Educ. 2016;16(1):7.
Pellón Arcaya M, Mansilla Sepúlveda J, San Martín Cantero D. Desafíos para la Transposición Didáctica y Conocimiento Didáctico del Contenido en Docentes de Anatomía: Obstáculos y Proyecciones. Int J Morphol. 2009;27(3):745–50.
Pratista GY. Students' perceptions of using ClassDojo in a teaching and learning process. Engl Educ J Engl Teach Res. 2023;8(1):77–90.
Przybylski AK, Rigby CS, Ryan RM. A motivational model of video game engagement. Rev Gen Psychol. 2010;14(2):154–66.
Reid S, Shapiro L, Louw G. How haptics and drawing enhance the learning of anatomy. Anat Sci Educ. 2019;12(2):164–72.
Ryan RM, Deci EL. Intrinsic and extrinsic motivations: classic definitions and new directions. Contemp Educ Psychol. 2000a;25(1):54–67.
Ryan RM, Deci EL. Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. Am Psychol. 2000b;55(1):68–78.
Ryan RM, Deci EL. Self-determination theory: basic psychological needs in motivation, development, and wellness. Guilford Press; 2017. Available from: https://www.guilford.com/excerpts/ryan.pdf
Singh K, Bharatha A, Sa B, Adams OP, Majumder MAM. Teaching anatomy using an active and engaging learning strategy. BMC Med Educ. 2019;19(1):149. https://doi.org/10.1186/s12909-019-1590-2
Streiner DL. Starting at the beginning: an introduction to coefficient alpha and internal consistency. J Pers Assess. 2003;80(1):99–103.
Suh A. Applying game design elements in the workplace. International Conference on Information Systems (ICIS 2015): Exploring the Information Frontier. Vol. 3. Fort Worth, TX, USA: Association for Information Systems; 2015. p. 1823–33.
Suh A, Wagner C, Liu L. Enhancing user engagement through gamification. J Comput Inf Syst. 2018;58(3):204–13.
Tan JW, Chong DKS, Ng KB, Car LT, Mogali SR. Rehearsal-based digital serious boardgame versus a game-free e-learning tool for anatomical education: quasi-randomized controlled trial. Anat Sci Educ. 2023;16:830–42.
Taylor L, Dyer T, Al-Azzawi M, Smith C, Nzeako O, Shah Z. Extended reality anatomy undergraduate teaching: a literature review on an alternative method of learning. Ann Anat. 2022;239:151817. Available from: https://www.sciencedirect.com/science/article/pii/S0940960221001436
Ten Cate OTJ, Kusurkar RA, Williams GC. How self-determination theory can assist our understanding of the teaching and learning processes in medical education. AMEE guide No. 59. Med Teach. 2011;33(12):961–73.
Tukey JW. Exploratory data analysis. Reading, MA: Addison-Wesely; 1977.
Van der Kaap-Deeder J, Soenens B, Ryan RM, Vansteenkiste M. Manual of the basic psychological need satisfaction and frustration scale (BPNSFS). Belgium: Ghent University; 2020.
Wilkinson K. The integration of mobile learning app-based quiz-games in higher education teaching of anatomical sciences [DProf Thesis]. London: Middlesex University; 2017.

AUTHOR BIOGRAPHIES

Lorena Latre-Navarro, M.D., is a teaching assistant in the Department of Human Anatomy and Histology at the University of Zaragoza, Spain. She teaches human anatomy to sport sciences students, and head and neck anatomy to dental students. Her research interests encompass anatomy education and health. She holds a Medical Degree and is currently a doctoral candidate in the Doctoral Program in Education at the University of Zaragoza's School of Doctoral Studies.

Alejandro Quintas-Hijós, Ph.D., is an associate professor in the Department of Education Sciences at the University of Zaragoza, Spain. He has professional experience as a high school philosophy teacher and as a professor of educational sciences at the university, where he instructs prospective early childhood and primary school teachers in didactics. His research interests encompass education and technologies, with a particular focus on gamification.

María-José Sáez-Bondía, Ph.D., is an assistant professor in the Department of Specific Didactics at the University of Zaragoza, Spain. She holds degrees in Veterinary Medicine and Biochemistry, and she is currently instructing prospective primary school teachers in experimental science teaching. Her research interests revolve around the field of didactics in experimental sciences.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Latre-Navarro L, Quintas-Hijós A, Sáez-Bondía M-J. The combined effects of an anatomy program integrating drawing and gamification on basic psychological needs satisfaction among sport sciences students: Results of a natural experiment. Anat Sci Educ. 2023;00:1–13. https://doi.org/10.1002/ase.2358