Macrothink Institute™

Journal of Studies in Education
ISSN 2162-6952
2024, Vol. 14, No. 2

Gamification in the Teaching of Embryology for the Medical Curriculum: Application and Evaluation of a Game

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Received: Dec. 10, 2023 Accepted: March 9, 2024 Published: May 1, 2024

doi:10.5296/jse.v14i2.21652 URL: https://doi.org/10.5296/jse.v14i2.21652

Abstract

The increasing number of studies on the use of active methodologies has promoted the application of such resources by professors in the field of morphology. Gamification has been the focus of increasing attention since the beginning of the last decade, its central idea is to

take advantage of the motivational potential of games for the classroom environment. This work sought to verify the reliability of an evaluation scale for educational games and the effectiveness of a board game as an active tool for teaching embryology. The potential and limitations of the scale used were also studied. To achieve this objective, an active practical class was held with medical students from a Brazilian higher education institution. The study included 215 students, of legal age, enrolled in the first to eighth phases of the course. The content addressed during the intervention referred to the period from the first to the eighth week of embryonic development, addressed through a board game. At the end of the activity, students were invited to answer a questionnaire to evaluate educational games. After data collection, exploratory factor analysis was performed using the IBM SPSS® Statistics 22.0 software. It was observed that the assertions Relevance3, Confidence4, Satisfaction3, Immersion1, Challenge2, Skill1, Social Interaction3 and Fun5R had the most significant factorial load. The results suggest that gamification can bring important benefits when well used.

Keywords: embryology, active methodology, gamification; game review template

1. Introduction

The teaching of embryology as a discipline of basic sciences is inserted in the areas of morphology, specifically related to the study of embryonic cells and embryonic and fetal development (Marcuzzo, 2019). The events that occur during this period, that is, the processes involved in formations and malformations, can often be difficult for beginning students to understand (Guo et al., 2021).

However, a solid foundation in embryology is of fundamental importance, as this discipline already is, and increasingly becomes, one of the most active branches of developmental biology, partly as a result of advances in the areas of cloning, embryonic stem cells and in vitro fertilization (Cyranoski, 2018; Guo et al., 2021).

Unlike the traditional curriculum, in the curriculum guided by active methodologies, the possibility of approaching in an integrative and collaborative way the various areas of knowledge involved in morphofunctional sciences, such as embryology, is envisaged. Currently, we find several active methodologies, such as problem-based learning, team-based learning, project-based learning, flipped classroom and gamification, for example, each one varies according to its purpose, such as stimulating competitiveness in a playful way in case of gamification (Burleson and Olimpo, 2016).

This is what appears in the use of games as an active tool for medical education, being increasingly used by educators to meet the learning needs of today's students (Iqbal and Ahmed et al., 2015; Muntasir et al., 2015; McCoy, Lewis, and Dalton, 2016; Bigdeli and Kaufman, 2017; Rutledge et al., 2018).

Educational games act as promoters in the development of cognitive skills, making players have to elaborate their strategies in order to overcome the challenges imposed on them (Gros, 2003).

Given the above, this research aimed to verify the effectiveness of a board game as an active tool for teaching embryology, as well as the reliability of an evaluation scale for educational games.

This study presents itself as a quasi-experimental modality of quantitative approach, in terms of general classification of research. This study was carried out with students from the 1st to the 8th phase of the Medicine course at a college in the Alto Vale do Itajaí region in the state of Santa Catarina, Brazil. All stages of the research were approved by the Research Ethics Committee under opinion number 5,310,394. (CAAE: 56194022.0.0000.5676).

317 students regularly enrolled in the morphofunctional scenario of the first semester of 2022 were invited to participate. The Epi Info software was used to account for the size of the sample, considering a minimum of 174 participants for a 95% confidence interval. 215 students participated in this study, of legal age, who expressed interest in the research by signing the Free and Informed Consent Form.

To carry out this study, a board game with a theme referring to the embryological period (1st to

8th week) was developed. The game mechanics involved teams progressing across the board by rolling dice. When falling into specific houses, the mediator teacher raffled off a question related to the theme, which should be answered by the team. This model sought to stimulate a cooperative and collaborative environment, in addition to communication skills and competitiveness among participants. After carrying out the activity, students were invited to respond to the instrument to assess the effectiveness of the board game, previously made available on the Google Forms platform. Questions were randomized to reduce the risk of common bias.

This instrument was based on the work proposed by Savi et.al (2010), from which assertions were extracted in order to measure the following parameters: attention, relevance, trust, satisfaction, immersion, challenge, skill, social interaction, fun and knowledge (variables latent).

For each of the assertions, students should state their level of agreement on a five-point Likert scale (1 - Strongly Disagree; 5 - Strongly Agree). Four assertions needed to be reversed because their text structure went in the opposite direction to the others of the same latent variable, namely: Immersion5, Fun4, Fun5 and Fun6 all contributed negatively to the constructs if they were maintained. The reversal of the answers occurs by changing the values answered as follows: 1 for 5, 2 for 4, 3 is kept as such, 4 for 2 and 5 for 1. In this way, the student is not affected, but his answers are adjusted to represent what you really wanted to measure.

After data collection, exploratory factor analysis was performed using the IBM SPSS® Statistics 22.0 software. In exploratory factor analysis, it was investigated whether the correlations of a set of observable variables could be explained by a smaller number of unobservable variables, called constructs (Vieira & Ribas, 2011).

In the specific case of the present research, the parameters are called latent variables because they cannot be measured directly, therefore the use of psychometric scales composed of phrases (Chart 1) measure the degree of agreement of the participants through a five-point Likert score.

2. Method

This study presents itself as a quasi-experimental modality of quantitative approach, in terms of general classification of research. This study was carried out with students from the 1st to the 8th phase of the Medicine course at a college in the Alto Vale do Itajaí region in the state of Santa Catarina, Brazil. All stages of the research were approved by the Research Ethics Committee under opinion number 5,310,394. (CAAE: 56194022.0.0000.5676).

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Chart 1. Assertions and their respective constructs.

Construct	Assertive	Phrase
Attention	Attention 1	There was something early on in the game that captured my attention.
	Attention 2	The game's interface design is attractive.
	Relevance 1	It was clear to me that the content of the game is related to things I already knew.
	Relevance 2	I enjoyed the game so much that I would like to learn more

Relevance		about the content it covers.
	Relevance 3	Game content is relevant to my interests.
	Relevance 4	I could relate the game's content to things I've seen, done, and thought about.
	Relevance 5	Game content will be useful to me.
Confidence	Confidence 1	The game was harder to understand than I would have liked.
	Confidence 2	The game had so much information that it was difficult to identify and remember important points.
	Confidence 3	The game's content is abstract, it was hard to keep your attention on it.
	Confidence 4	Game activities were very difficult.
	Confidence 5	I couldn't understand a good portion of the game's material.
Satisfaction	Satisfaction 1	Completing the game's exercises brought me a sense of accomplishment.
	Satisfaction 2	I learned a few things from the game that were either surprising or unexpected.
	Satisfaction 3	The comments and feedbacks during the game helped me to feel rewarded for my effort.
	Satisfaction 4	I felt good when completing the game.
Immersion	Immersion 1	I didn't notice the time pass while playing.
	Immersion 2	I lost awareness of my surroundings while playing.
	Immersion 3	I felt more in the game environment than in the real world.
	Immersion 4	I tried hard to get good results in the game.
	Immersion 5	There were times when I wanted to quit the game.
	Immersion 6	I felt encouraged to learn from the game.
Challenge	Challenge 1	I enjoyed the game and didn't feel anxious or bored.
	Challenge 2	The game kept me motivated to continue using it.
	Challenge 3	My skills gradually improved by overcoming challenges.
	Challenge 4	The game offers new challenges at an appropriate pace.
	Challenge 5	The game is suitably challenging for me, the tasks are neither

		too easy nor too difficult.
Ability	Ability 1	I felt successful.
	Ability 2	I quickly reached the goals of the game.
	Ability 3	I felt competent.
	Ability 4	I felt like I was making progress as the game progressed.
Social interaction	Soc Int 1	I felt like I was collaborating with other colleagues.
	Soc Int 2	Game collaboration helps learning.
	Soc Int 3	The game supports social interaction between players.
Entertainment	Entertainment 1	I enjoyed using the game for the proposed time.
	Entertainment 2	When interrupted I was disappointed that the game was over.
	Entertainment 3	I would play this game again.
	Entertainment 4	Some things in the game pissed me off.
	Entertainment 5	I was rooting for the game to end soon.
	Entertainment 6	I found the game a bit 'stopped'.
Knowledge	Knowledge 1	After the game I can remember more information related to the proposed topic.
	Knowledge 2	After the game I can better understand the proposed theme.

Source: adapted from Savi et al., 2011.

In the initial stage of the analysis, all assertions were examined together, regardless of the parameter with which they would be associated. To determine whether there were enough significant correlations between the items to justify the execution of factorial analysis, statistical analysis was performed using the Kaiser-Meyer-Olkin (KMO) test. KMO values must be greater than 0.70 for the analysis to be justified. Subsequently, Bartlett's sphericity test was used to test the hypothesis that there is no relationship between the measurable variables. The higher the value, the greater the confidence and the relationship between the variables (Hair et al., 2009). Both the KMO and Bartlett tests indicated that there was a relationship between the measurable variables, confirming that they were amenable to exploratory factor analysis.

After that, each of the scales used to measure the evaluation parameters of the educational game were tested in the same way, but individually, because in this step, in addition to the KMO test and Bartlett's sphericity test, the factor loadings (CF) of each measurable variable and Cronbach's alpha (CA).

Factor loadings are the correlation of each assertion (measurable variable) with the construct (latent variable) related to it. Factor loadings are the means of interpreting the role that each measurable variable has in defining the latent variable. Larger factor loadings make the measurable variable more representative of the construct.

Another analysis involved Cronbach's alpha test, which is a reliability coefficient that assesses the internal consistency of the scale, with an accepted minimum limit of 0.70, which may decrease to 0.60 in the case of exploratory research (Hair et al., 2009).

After that, the calculation of the factorial scores of each construct was carried out. Factorial score is the composite measure of each construct, computed for each respondent. It is based on the factor loadings of all construct variables (Hair et al., 2009).

For the purpose of analyzing the students' perception of each construct, the factor scores were categorized as low (minimum to 25%), regular (25% to 50%), satisfactory (50% to 75%) and high (75% to 100%). In this way, it was possible to evaluate the students' perception in relation to each evaluation parameter of the educational game.

We then proceeded to analyze the percentage distribution of participants in each of these items, in order to assess the frequency distribution of these perceptions.

3. Results

The results of the analyzes are shown in Table 1.

Table 1. Analysis of latent and measurable variables

Construct	Variable	KMO	Bartlett	CF	AC
Attention	Attention 1	0,500	33,712	0,832	0,545
	Attention 2			0,832	
Relevance	Relevance 1	0,799	340,301	0,596	0,793
	Relevance 2			0,719	
	Relevance 3			0,832	
	Relevance 4			0,757	
	Relevance 5			0,824	
Confidence	Confidence 1	0,838	440,297	0,762	0,850
	Confidence 2			0,804	

	Confidence 3			0,812	
	Confidence 4			0,818	
	Confidence 5			0,777	
Satisfaction	Satisfaction 1	0,778	260,317	0,817	0,788
	Satisfaction 2			0,645	
	Satisfaction 3			0,842	
	Satisfaction 4			0,826	
Immersion	Immersion 1	0,808	317,416	0,830	0,786
	Immersion 3			0,680	
	Immersion 4			0,795	
	Immersion 5R			0,676	
	Immersion 6			0,746	
Challenge	Challenge 1	0,834	370,522	0,718	0,828
	Challenge 2			0,837	
	Challenge 3			0,810	
	Challenge 4			0,785	
	Challenge 5			0,700	

Ability	Ability 1	0,839	504,392	0,907	0,893
	Ability 2			0,861	
	Ability 3			0,885	
	Ability 4			0,833	
Social interaction	Soc Int 1	0,637	174,727	0,708	0,696
	Soc Int 2			0,837	
	Soc Int 3			0,862	
Entertainment	Entertainment 1	0,800	355,248	0,761	0,809
	Entertainment 3			0,768	
	Entertainment 4R			0,693	
	Entertainment 5R			0,813	
	Entertainment 6R			0,766	
Knowledge	Knowledge 1	0,500	177,594	0,936	0,857
	Knowledge 2			0,936	

Caption: CF = Factorial load; AC = Cronbach's alpha KMO = Kaiser-Meyer-Olki test; R= reversed variable. It was considered statistically significant ($p<0.001$).

Source: prepared by the authors.

As shown, the factors Attention and Knowledge showed some inconsistency in the set of evaluated parameters (Attention with Cronbach's alpha and KMO lower than desired and Knowledge with KMO lower than recommended by the literature). In addition, Attention1 and Attention2 have the same factorial load (0.832), as well as Knowledge1 and Knowledge2 (0.936), corroborating the little variability between the assertions in their relationship with their construct.

Regarding the variables Immersion2 and Fun2, they were eliminated because of their low factorial load or because they did not contribute to the required internal consistency of the scale.

Table 2 presents the results of the analysis of frequency and percentage performed, considering the categories of perception established for each construct of evaluation of the educational game.

Table 2. Evaluation of frequency and percentage of evaluated constructs

Construct	**Category**			
	Low	Regular	Satisfactory	High
	F/P	F/P	F/P	F/P
Attention	1/0,5	25/11,6	102/47,4	87/40,5
Relevance	0/0,2	8/3,8	79/36,7	128/59,5
Confidence	128/59,4	73/34,0	10/4,7	4/1,9
Satisfaction	0/0,0	20/9,3	121/56,3	74/34,4
Immersion	3/1,4	23/10,7	111/51,6	78/36,3
Challenge	1/0,5	12/5,6	128/59,8	73/34,1
Ability	9/4,2	34/15,8	122/56,7	50/23,3
Social interaction	1/0,5	4/1,9	114/53,0	96/44,6
Entertainment	4/1,5	19/8,9	108/50,5	83/38,8
Knowledge	3/1,4	11/5,1	114/53,0	84/40,5

Caption: F= Frequency; P= Percentage.

Source: prepared by the authors.

As can be seen in Table 2, 87.9% of students considered that the game presented something interesting at the beginning that captured the player's attention and understood that the game's interface was attractive. As for Relevance, 96.2% of participants concentrated their answers on the satisfactory and high categories, demonstrating that they understand the game content is relevant to the context in which it is inserted. As for Confidence, 93.4% of the participants concentrated their responses in the low and regular categories, demonstrating that they did not find it difficult to solve the questions proposed by the game. With regard to Satisfaction, it was observed that 90.7% of students indicated a high perception. About the Immersion construct, it was shown that 87.9% of the game participants were involved in the activity. Regarding the Challenge, regarding the fact that the game is challenging and compatible with the player's skill level, as can be seen, 93.9% of the players considered the game challenging. As for the Skill construct, curiously, it recorded low perception (4.2%). The Social Interaction construct showed very significant results of 97.6%. For the Fun construct, 89.3% of the students considered the game pleasant and fun. Finally, 93.5% of the participants indicated satisfactory and high perception regarding the Knowledge construct.

4. Discussion

Games can be incorporated into the field of andragogy, the principle is that educational

games encourage self-direction and independence, in addition to providing more active learning (Malliarakis, et al,. 2018).

In view of our results, in relation to attention, this is a construct that deserves caution, despite the good results, this should be considered with reservations due to the limitations of the scale, since two assertions are not enough to represent it. According to the ARCS model (attention, relevance, confidence and satisfaction), attention is a motivational element and also a prerequisite for learning. The challenge is to obtain and maintain a satisfactory level of student attention throughout a learning period (Keller, 2009).

In future research, it would be worth understanding if attention is limited to the beginning of the game, due to it being something new and interesting, or if such attention is perpetuated throughout its use, since the proposal of an educational game is that the player stays emotionally connected throughout the duration of the activity, evoking his involvement (Mullins, 2020).

However, with regard to attention as a competence to be achieved, it is known that the use of games contributes to the creation of a unique environment, promoting the development of attention and other cognitive skills such as memorization (Furió et.al, 2013).

Although necessary, the student's attention and curiosity are not sufficient conditions for motivation to study. Students also need to realize that the educational proposal is consistent with their objectives, that they can connect the learning content with their professional future. Relevance can be understood as the level of association that students can perceive between their prior knowledge and new information (Huang; Huang; Tschopp, 2010). Attention and relevance are therefore constructs that are interrelated, as a basis for meaningful learning, proposed by the andragogical model, since the student considers previous experiences when learning (Loeng, 2018).

In view of the results, in our study, it can be observed that the participants understood that the content of the game is related to aspects of embryology, which they were aware of and were encouraged to learn more about the content addressed by it, realizing the practical usefulness and theory of the educational game used, thus becoming relevant.

With regard to the trust construct, the correct name for this construct could be difficulty, depending on the text involved in each of the assertions used to calculate its score. Since four of the five assertions that represent this construct have the word “difficult” in their structure, referring students to aspects related to difficulty and not to confidence. However, it was decided to keep the name of the original work. Despite this, the assertions presented a high factorial load, indicating that the student may have interpreted the questions as belonging to an analysis of the game's degree of difficulty.

As for the satisfaction construct, this is a subjective feeling of the student, and is associated with accomplishing something (completing tasks, overcoming challenges, defeating opponents, among others) that occurs in the relationship between individual skills and challenges (Busarello, 2016). That is, it is involved in providing the student, as early as possible, with

opportunities for them to apply what has been learned. Students should feel that the effort put into studying was appropriate and brought results. According to the results of this construct, students understand that completing the exercise provided a sense of achievement, reward, well-being and learning. In theory, the participants already had prior knowledge of the theme addressed in the game, as a result of their regular classes. In this way, the result points to positive aspects of the game, as a means of bringing new knowledge, not covered by the regular process.

As in the study by Silva (2020), who used a game in the context of the physics discipline, where there was evidence of an increase in the desire to achieve goals during learning, in the interest in learning relevant content and in self-confidence when feeling that they were progressing by his own effort, thus providing the satisfaction of accomplishment.

Regarding immersion, this can be used to describe the participant's degree of involvement with the activity, being divided by some authors into three levels of depth: engagement, involvement and total immersion (Cheng, et.al 2013). The results of the Immersion construct show that students tried to obtain good results and, above all, feel encouraged to learn with the game, which seems to us to be an encouraging return for the development of other similar resources that contribute to the support of the educational process.

The need to eliminate the statement Immersion2 due to its non-contribution to the internal consistency of the scale shows that, despite the level of immersion involved, there was no detachment from reality on the part of respondents, which is also positive as a characteristic of an educational game. The word “consciousness” in the context of this assertion most likely could have been misinterpreted by the students, taken in the literal sense of “loss of consciousness” and not in the figurative sense of “loss of the notion of time” during the game.

In addition, Immersion5R was a reversed variable, as it originally denotes the opposite effect to deep involvement, which shows that this assertion should be revised so that it better represents the construct.

The impact of immersion on learning derived from the use of educational games still needs to be further investigated, research suggests that very high levels of immersion in the activity (escape from reality) do not necessarily suggest better levels of educational performance (Cheng, 2015; Schrader & Bastiaens, 2012).

Immersion can also be directly related to increasing the student's chances of remembering the knowledge worked on during the game (Chametzky, 2014).

In gamification, the challenge is essential (Aldemir, 2018). In this construct, the assertions questioned whether the game brought anxiety, if it had been motivating, if it offered new challenges at an appropriate pace, enabling the balance between easy and difficult tasks. Having the level of responses obtained is important, as educational games cannot be easy to the point of not attracting the students' desire to play, but equally they must not be difficult so that participants do not even try to start playing. In the present work, the material used proved to be suitable for medical students, keeping them interested and challenged in the same proportion.

As found in the study by Silva, Steinmacher & Conte (2017), who applied a game in a context different from ours, the participants evaluated that the game evolves at an adequate pace and that it does not become monotonous, offering challenging tasks.

The challenge in the right measure is important for students' learning, it encourages and motivates them so that they can overcome the task (Malliarakis, et al,. 2018).

Skill is related to "knowing how to do" something. Our results indicate that most players felt skilled, having achieved the objectives proposed by the task.

However, although in a small way, this construct recorded the highest percentage categorized as low (4.2%), which may indicate a certain degree of lack of self-confidence, lack of self-esteem, modesty or non-recognition of one's own results. It is interesting to observe the difference already mentioned to consider the appropriateness of using this construct or its eventual modification, in order to capture any bias not identified in the present work.

The impact of interpersonal relationships on activities between individuals can be crucial (Ryan and Deci 2002). Therefore, the type of social interaction that is likely to occur as a result of a gamified activity may affect learning outcomes (Sailer, Homer 2020). Game mechanics involving collaboration and competition, when added together, can be considered particularly important in this scenario (Rigby, Ryan 2011).

In the context of games, collaboration has the role of affecting relationships, allowing teamwork and the experience of the individual to feel useful and important to the other members of his team (Sailer, Homer 2020). The competitive character of the activity can put pressure on individuals, leading to a constructive effect on the proposed dynamic (Burguillo, 2010).

People are more attracted to activities involving games, as they consider that they increase attention and learning. In addition, the dynamics of the game helps to reduce the stress situation and can work as a mechanism to promote the socialization of individuals (Zichermann and Cunninghan, 2011).

Our results for this construct suggest that the game encourages collaboration between participants and that this, ultimately, provides the stimulus for better learning, the ultimate goal of the task.

According to the measured responses, the participants would be willing to use the game for a long time and would play it again. He was not considered irritating, "stopped", something to be wished away. Regarding the need to eliminate the statement Divertimento2, it shows that the practice has an adequate measure. Therefore, it is not considered a more important task than any other, by the students, because what is wanted is that the game is a complementary educational resource and not something addictive and that diverts students from their regular activities.

A game with a pedagogical purpose must add value beyond the boundaries of fun, that is, the fun quality of the gamified intervention must serve as a motivating and facilitating means for

the participant's learning (Deterding et al,. 2011; Antônio, Teixeira and Cavalcanti, 2017).

According to Ritterfeld (2006), there are three main approaches that can be adopted to combine play with education: a reinforcement approach, where entertainment is offered as a reward for learning; a motivational approach, where entertainment is used to attract the student's interest and attention in preparation for learning, and a mixed approach, where the learning procedure itself aims to be fun. The latter is likely to be more effective, having the potential to take advantage of the inherent pleasure of learning, in addition to the pleasure provided by games or game elements (Gentry, 2018).

Knowledge involves participants remembering information about facts, theories, methods, classifications, among others. As for inconsistencies about the Knowledge construct, like Attention, this also has scale limitations, due to the low number of assertions. However, the results indicate that the game was important for the participants in terms of remembering information related to the themes presented and better understanding them during the game. It is suggested that gamification is an appropriate tool to promote better knowledge retention (Putz, 2020).

In future studies, we propose to modify certain statements to prevent any misinterpretation by the participants. During our analysis, we found some statements that had been reversed, and we would like to adjust them accordingly. Furthermore, we need to include additional statements to the constructs that showed lower reliability. This will help us to better represent these constructs in our research.

5. Conclusion

Our research indicates that an embryology-themed game can be an effective educational tool. We were also able to create an evaluation instrument to measure the effectiveness of the game, despite finding some inconsistencies. The evaluation showed that the game received high scores in important parameters for an educational resource, such as immersion, challenge, skill, fun, and social interaction. These parameters, when used effectively, can enhance the learning process.

Acknowledgment

The authors would like to thank the Graduate Program in Morphofunctional Sciences at the Federal University of Ceará - Brazil.

References

Aldemir T, Celik B, Kaplan, G. 2018. A qualitative investigation of student perceptions of game elements in a gamified course. *Computers in Human Behavior, 78,* 235-254. https://doi.org/10.1016/j.chb.2017.10.001

Bigdeli, S., & Kaufman, D. (2017). Digital games in medical education: Key terms, concepts, and definitions. *Medical journal of the Islamic Republic of Iran, 31,* 52. https://doi.org/10.14196/mjiri.31.52

Burguillo JC. 2010. Using game theory and competition-based learning to stimulate student motivation and performance. *Computers & Education, 55*(2), 566-575. https://doi.org/10.1016/j.compedu.2010.02.018

Burleson, KM. and Olimpo, J. T. (2016) 'ClueConnect: A word array game to promote student comprehension of key terminology in an introductory anatomy and physiology course', Advances in Physiology Education. *American Physiological Society, 40*(2), 223-228. https://doi.org/10.1152/advan.00106.2015

Busarello RI. 2016. Gamification Approaches to Learning and Knowledge Development: a theorical review. *New Advances in Information Systems and Technologies.* Springer, Cham, 2016. 1107-1116. https://doi.org/10.1007/978-3-319-31232-3_105

Chametzky, B. (2014). Andragogy and engagement in online learning: Tenets and solutions. *Creative education,* 2014 https://doi.org/10.4236/ce.2014.510095

Cheng MT, Su T, Huang WY, & Chen JH. (2014). An educational game for learning human immunology: What do students learn and how do they perceive? *British Journal of Educational Technology, 45*(5), 820-833. https://doi.org/10.1111/bjet.12098

Cheng MT, She HC, Annetta LA. (2015). Game immersion experience: its hierarchical structure and impact on game-based science learning. *Journal of computer assisted learning, 31*(3), 232-253. https://doi.org/10.1111/jcal.12066

Cyranoski D. (2018) How human embryonic stem cells sparked a revolution. Nature, *555*(7697), 428-430. https://doi.org/10.1038/d41586-018-03268-4

Deterding S, Dixon D, Khaled R, Nacke L. 2011. From game design elements to gamefulness: defining "gamification". In A. Lugmayr (Ed.), *Proceedings of the 15th International Academic Mindtrek Conference: Envisioning Future Media Environments* (pp. 9-15). New York: ACM. https://doi.org/10.1145/2181037.2181040

DiStefano C, Zhu M, Mîndrilă D. (2009). Understanding and using factor scores: Considerations for the applied researcher. *Practical Assessment, Research and Evaluation, 14*(20), 1-11.

Furió D, González-Ganced S, Juan MC, Seguí I, Costa M. (2013). The effects of the size and weight of a mobile device on an educational game. *Journal Computers & Education, Virginia, 64,* p. 24-4. https://doi.org/10.1016/j.compedu.2012.12.015

Gentry, S, Ehrstrom, BLE, Gauthier, A, Alvarez, J., Wortley, D, van Rijswijk, J, & Zary, N. (2018). Serious gaming and gamification interventions for health professional education. *The Cochrane Database of Systematic Reviews, 2018*(6). https://doi.org/10.1002/14651858.CD012209.pub2

Guo Y. et al. (2021) Blended learning model via small private online course improves active learning and academic performance of embryology. *Clinical Anatomy,* n. September, p. 1-11. https://doi.org/10.1002/ca.23818

Gros, B. (2003). The impact of digital games in education. *First Monday, 8*(7), 6-26.

Hair JF, Black WC, Babin BJ, Anderson RE, Tatham RL. (2009). *Análise Multivariada de Dados* (6th ed.). Porto Alegre, RS: Bookman Editora.

Huang W, Huang W, Tschopp J. 2010. Sustaining iterative game playing processes in DGBL: The relationship between motivational processing and outcome processing. *Comput. Educ., 55*(2), 789-797. https://doi.org/10.1016/j.compedu.2010.03.011

Iqbal, S., & Ahmed Bhatti, Z. (2015). An investigation of university student readiness towards m-learning using technology acceptance model. *International Review of Research in Open and Distributed Learning, 16*(4), 83-103. https://doi.org/10.19173/irrodl.v16i4.2351

Keller JM. (2009). *Motivational Design for Learning and Performance: The ARCS Model Approach*. Springer.

Loeng, S. (2018). Various ways of understanding the concept of andragogy. *Cogent Education, 5*(1), 1496643. https://doi.org/10.1080/2331186X.2018.1496643

Malliarakis, C, Tomos, F, Shabalina, O, & Mozelius, P. (2018). Andragogy and EMOTION: 7 key factors of successful serious games. In *ECGBL 2018 12th European Conference on Game-Based Learning* (p. 371). Academic Conferences and publishing limited.

Marcuzzo S.et al. (2019). Estratégias para motivar a aprendizagem da embriologia: um relato de experiência no curso de enfermagem da Universidade Federal do Rio Grande do Sul. *Revista Internacional de Educação Superior*. https://doi.org/10.20396/riesup.v5i0.8653470

Mullins JK, & Sabherwal, R. (2020). Gamification: A cognitive-emotional view. *Journal of Business Research, 106,* 304-314. https://doi.org/10.1016/j.jbusres.2018.09.023

McCoy L, Lewis, JH, & Dalton, D. (2016). Gamificação e multimídia para educação médica: uma revisão da paisagem. *Journal of Osteopathic Medicine, 116*(1), 22-34. https://doi.org/10.7556/jaoa.2016.003

Muntasir, M. et al. (2015).The gamification of medical education: a broader perspective. *Medical education online, 20.* https://doi.org/10.3402/meo.v20.30566

Nunnally JC, Bernstein IH. (1994). *Psychometric theory* (3rd ed.). New York: McGraw-Hill. https://doi.org/10.1037/018882

Podsakoff PM, MacKenzie SB, Lee JY, Podsakoff NP. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology, 88*(5), 879-903. https://doi.org/10.1037/0021-9010.88.5.879

Podsakoff PM, MacKenzie SB, Podsakoff NP. (2012). Sources of Method Bias in Social Science Research and Recommendations on How to Control It. *Annual Review of Psychology, 63*(1), 539-569. https://doi.org/10.1146/annurev-psych-120710-100452

Podsakoff PM, Organ DW. (1986). Self-reports in Organizational Research Problems and

Prospects. *Journal of Management Information Systems, 12*(4), 531-544. https://doi.org/10.1177/014920638601200408

Putz LM, Hofbauer F, Treiblmaier H. (2020). Can gamification help to improve education? Findings from a longitudinal study. *Computers in Human Behavior, 110,* 106392. https://doi.org/10.1016/j.chb.2020.106392

Rigby S, Ryan RM. (2011). *Glued to games: how video games draw us in and hold us spellbound.* Santa Barbara: Praeger. https://doi.org/10.5040/9798400658105

Ritterfeld, & Weber, R. (2006). Video games for entertainment and education. *Playing video games: Motives, responses, and consequences,* 399-413.

Rutledge, C. et al. (2018). Gamification in action: theoretical and practical considerations for medical educators. *Academic Medicine, 93*(7), 1014-1020. https://doi.org/10.1097/ACM.0000000000002183

Sailer M, Homner, L. (2020). The gamification of learning: A meta-analysis. *Educational Psychology Review, 32*(1), 77-112. https://doi.org/10.1007/s10648-019-09498-w

Savi R, Von Wangenheim CG, Ulbricht V, Vanzin T. (2010). Proposta de um Modelo de Avaliação de Jogos Educacionais. *Renote*, *8*(3). https://doi.org/10.22456/1679-1916.18043

Silva, J. B. (2020). Gamificação na sala de aula: avaliação da motivação utilizando o questionário ARCS. *Revista Prática Docente, 5*(1), 374-390. https://doi.org/10.23926/RPD.2526-2149.2020.v5.n1.p374-390.id632

Silva, W., Steinmacher, I., & Conte, T. (2017). Apoiando o Ensino de Diagrama de Atividades através de um jogo educacional. In *Anais do XXV Workshop sobre Educação em Computação.* SBC. https://doi.org/10.5753/wei.2017.3533

Schrader C, & Bastiaens TJ. (2012). The influence of virtual presence: Effects on experienced cognitive load and learning outcomes in educational computer games. *Computers in Human Behavior, 28*(2), 648-658. https://doi.org/10.1016/j.chb.2011.11.011

Vieira PRC, Ribas JR. (2011). Análise multivariada com uso do SPSS. Rio de Janeiro, RJ: Editora Ciência Moderna Ltda.

Zichermann G, & Cunningham C. (2011). Gamification by design: Implementing game mechanics in web and mobile apps. " O'Reilly Media, Inc.".