Digital Gamification: An Innovative Pedagogy for Anatomy and Physiology Course Among Medical-Surgical Nursing Students

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Abstract:
Background: Being an educator for such digitally-oriented generation has become a great challenge for higher education educators that requires changes in teaching–learning approaches to fulfil the academic objectives of all domains. As a result of the outbreak of COVID-19 this change has become a must. Games introduce to us great chances to achieve that in a funny way. Since anatomy and physiology as a subject matter containing lots of diagrams and difficult concepts especially when being taught to first level nursing students, this will act as a challenge to prove the effectiveness of such a newly-induced approach. **Aim of the Study:** To investigate the effectiveness of digital gamification an innovative pedagogy for anatomy and physiology course among medical-surgical nursing students. **Sampling:** Random sample of 100 students, 50 students for each. **Design:** A longitudinal experimental research design was used in this study. **Setting:** The study was conducted in the Anatomy and Physiology laboratories of the Nursing Department, College of Applied Medical Sciences at King Faisal University. **Tools:** The data were collected using Lab Learning Activities Effectiveness Scale as well as midterm and final exams. **Results:** Mobile educational games significantly affect students' learning as well as attitudes towards themselves, teachers, course content. The students reported significant raise in their learning management skills, information retainability, attentiveness and motivation in laboratory sessions as compared to using traditional tasks. **Conclusion:** Digital games utilization greatly improves the students' achievement and enhances positive attitudes while the conduction of Anatomy and Physiology course. **Recommendation:** Use mobile digital games not only in such course but also to try it with other courses and specialties.

Keywords: Anatomy and physiology, Digital gamification, Innovative pedagogy, Medical-surgical & Nursing students

Introduction

During the past decade, digital learning designs have been increasingly used in teaching practices in higher education. UNESCO emphasizes that digital learning can transform teaching practices, improve the quality and enhance the sustainability of higher education **(UNESCO, 2020)**.

One of the outcomes and a way to control the outbreak of COVID-19 virus was that universities worldwide abruptly stopped face-to-face teaching and switched to technology-mediated teaching **(Radanliev et al., 2020 & Crawford et al., 2020)**. As a result, the use of technology in the learning process of students from different disciplines became essential and is the only way to teach, communicate and collaborate for months.

Digital game-based learning (DGBL) is being used progressively as an alternative learning means to teach science in higher education. Many varieties of digital game formats exist currently for science learning, alongside diverse methods for their implementation and evaluation **(Brown et al., 2018)**. Visionaries propose strong claims for the educational benefits of computer games, but there is a need to assess those claims with scientific research and ground them in evidence-based theories of how people study. Additionally, future research is needed to identify the cognitive, motivational, affective, and social processes that underlie learning with educational computer games **(Mayer, 2019)**.

The greatest challenges for educators are nurturing proper attitudes among students. Nursing education is not an exception of that. Future nursing education is challenged to develop innovative and effective

programs that align with current changes in health reasoning skills, evidence-based knowledge, and professional autonomy. Game-based learning might have a positive impact on medical education students as it was proved that games promote student engagement and satisfaction, and reassure collaboration and teamwork among students when used formatively. Gamification may also enable students retain knowledge **(Lorenzo et.al., 2020; Lu et.al., 2018 & Johnsen et al., 2018)**. Its use was highly recommended by nursing students as they perceived it as educationally valuable **(Johnsen et al., 2018)**.

A game-based approach to teach and learn Anatomy of the liver and portal venous system was conducted with a 30-minute interactive lab station involving two different game-based activities. Many students offered feedback that the activities were effective and enjoyable. In addition, the average student scores on two subject exam questions increased **(Hill & Nassrallah, 2018)**.

A study conducted by **Kamnardsiri et al. (2017)** shows that the electronic system offered improving in language skills of the students. In addition, the students had the sense of control and concentration while playing the game, along with a good learning achievement as well.

Inclusion of game elements in learning environments to increase motivation and learning outcome has become more popular nowadays **(Kober et al., 2020)**. A longitudinal study conducted in four German universities to assess the students' acceptance overtime of technology-mediated learning showed that students enjoyed the technology-mediated teaching more, although social isolation was the most negatively indicated sign **(Vladova et al., 2021)**.

Using commercial games as part of students' educational experience, could serve as objects of reflection in formal educational settings for increasing students' motivation **(Rüth & Kaspar, 2021)**, students' engagement, and cross-curricular skills as well **(Huizenga et al.,2017)**.

A meta-analysis was conducted to systematically synthesize research findings on effects of gamification on cognitive, motivational, and behavioural learning outcomes. Results from random effects models showed significant effects of gamification on cognitive, motivational and behavioural learning outcomes. The results recommend gamification as an effective method for instruction **(Sailer & Homner, 2020)**. Generally, research showed that digital learning designs in the form of blended learning and distance learning were equally or more effective compared to traditional teaching **(Ødegaard et al., 2021)**.

care and to educate nurses with a high level of clinical Gamification applications could be very diverse, and research has frequently failed to recognise that there are different game design elements at work that can afford various modes of social interactions, and learning arrangements for learners **(Sailer et.al., 2017b)**.

Gamification has been studied in different research contexts. Whereas the majority of studies found in reviews focusing on education were conducted in higher education settings, some of them were also performed in primary and secondary school settings **(Dichev& Dicheva, 2017)**.

A study was conducted in Sweden to describe and evaluate nursing students' experiences of the pedagogical transition from traditional campus-based learning to distance learning using digital tools. The results showed that a majority of students preferred campus-based education and experienced deterioration in all investigated dimensions after the pedagogical transition. About one-third of the students appeared to prefer distance learning using digital tools **(Ulrica et.al., 2021)**. In another study, 90% of nursing students confirmed that digital media improved the acquisition of nursing knowledge **(Rodríguez-Almagro, 2021)**.

Significance of the Study

Currently, we are faced with a society engrossed in globalization and native technology, especially with presence of COVID-19 infection causing a great challenge in the university teaching staff to shift so fast from traditional approaches to digitally oriented teaching-learning tools. The gamification gathers the characteristics that allow to motivate and achieve an active and significant learning **(Solís et al., 2018; Aburahma & Mohamed, 2015 & ElKocany et al., 2021)**.

Aim of the study

This study aimed to investigate the effectiveness of digital gamification an innovative pedagogy for anatomy and physiology course among medical-surgical nursing students.

Research Hypotheses

Given that such study is aimed to examine the perception of nursing students towards the effectiveness of gamification as a new trend to learning and to assess their level of satisfaction as well as achievement in term of exams as compared to the control group, so the hypotheses regarding such areas were as follows:

▪ Students who are playing mobile digital learning games will possess more positive perception towards Learning Management Skills & Information Retention Abilities than those who are going through routine lab. activities.

▪ Students who are playing mobile digital learning games will display more positive self, professor and course content specific-related attitudes than those who will attend to routine lab. activities.

▪ Students who are playing mobile digital learning games will report more attentiveness and motivation throughout anatomy lab time than those who will be passing through routine lab. activities.

▪ Students who are experiencing digitalization in learning will accomplish higher achievement and retention of knowledge than those who are taught through usual lab. activities.

Material and Methods:

Research design: This study conducted using longitudinal experimental research design.

Setting: The study conducted at the Anatomy and Physiology labs of the College of Applied Medical Sciences, Nursing Department, King Faisal University, Saudi Arabia according to the schedule of Anatomy and Physiology course of different groups.

Sample: The sample comprised 100 students of level one who were taught by the researchers and enrolled to Anatomy and Physiology (I) course in College of Applied Medical Sciences at King Faisal University, department of Nursing (N=100). Since the students already divided randomly by the student affairs in to clinical groups and the instructors assigned randomly to teach the groups. Those who were selected to participate in the research and assigned to digital gaming and usual lab activities were also hired through randomization. Thus, each group comprised 50 students who accepted to participate in the research study.

Research Tools: Two tools were used by the researchers for the purpose of data collection after a thorough review of related literature.

Tool 1: First tool was **Lab Learning Activities Effectiveness Scale** which was developed to measure students' perception regarding the different kinds of learning activities or modalities used throughout laboratory sessions to assist in learning for both groups. This tool comprised three main sections which are Personal and academic data, Student specific perception, Overall satisfaction level measured on a 10-points scale. **Part I** included data like: University e-mail, consent for approval to participate, group number, Instructor name, Kind of learning activities experienced during lab. time. **Part II** composed of 5 sections which are: General Learning Management Skills & Information Retention Abilities, Attentiveness and Motivation in lab. Session & Class Control, Course Content Specific Related attitudes, Professor-related attitudes and the Self-related attitudes. Statements were measured against 4-point likert scale ranged from

strongly agree to strongly disagree **Part III** was only investigating the overall satisfaction level from learning anatomy and physiology through such kind of activities experienced throughout lab. time.

Tool 2: Second, Anatomy and Physiology midterm and final exams were used to compare the extent of achievement of learning objectives in both groups.

Validity and reliability:

The content validity was tested for clarity, comprehensiveness, appropriateness, and relevance and reviewed by five experts in medical-surgical nursing and nursing education fields. Modifications were done according to the panel judgment to ensure clarity of sentences and appropriateness of the content.

BM SPSS statistics ver. 20 was applied to analyse all the data gathered. Using Pearson Test for internal consistency, the items' reliability ranged from 0.7 to 0.966.

Pilot study

A pilot study was applied on 30 students who were excluded from the study itself to test ease of use and clarity of games and their questions for the validity and reliability of the instrument. An hour was devoted to conducting mobile gaming activities over a fifteen-week period. Then the students were required to fill in the post-MGBLLAs integration questionnaires.

Field work:

The study conducted using the ADDIE instructional model, which stands for assessment, designing, developing, implementation and evaluation phases.

Assessment Phase:

This phase was including reviewing of literature related to game-based learning and its impact on students' attitudes and achievement as well as related literature and Anatomy and Physiology (I) course content and the intended learning outcomes. The objectives were to get acquainted with the research problem to develop the study tools.

Designing & Developing Phase:

For enquiring and putting the light on such shift to digitalization, the main researcher tried to shift most of laboratory activities which were done on paper-based drawings, diagrams and mannequins to sketches and diagrams with blank instructions as well as crossword activities in order to form games as well as objective questions using different applications like Kahoot, Quizlet, Quizalize, Quizizz. Links were added to a digital class that created on EdModo. EdModo was used also as a medium to motivate students and communicate individually too with student in the digital group.

Tools also were developed and tested for their validity and reliability and all recommended modifications were done. Then the **Lab Learning Activities Effectiveness Scale** was uploaded on

Google Forms to collect data electronically for piloting and for the study itself, while for the achievement tests took the form of paper-based exams.

Implementation Phase:

Data collection was done in the Anatomy and Physiology laboratory which consumed one hour weekly along the 15 weeks of the winter semester of the academic year, 2019/2020 from 1/9/2020 to 14/1/2021.

Students of digital gaming used their mobile smart phones to log into the games during lab. time, and even they were permitted to practice at home whenever they view it would be helpful to learning. While the other routine activities groups who attended with different lecturers were taught through paper-based activities.

Evaluation Phase:

During the last laboratory session, students of all groups were sent a link to the **Lab. Learning Activities Effectiveness Scale** to join through their own mobile phones in order to obtain their different attitudes regarding the effectiveness of the kind of laboratory activities they have been taught through during the laboratory sessions all through the semester. On the other hand, the **Anatomy and Physiology Achievement Test**s were held using paper-form for both groups in form of two time-lapsed measurements in the midterm and at the end of the semester in order to compare achievement of students taught by both approaches.

Ethical Considerations:

An ethical clearance was obtained from the college postgraduate and scientific research committee as well as from the Deanship of Scientific Research was obtained. Also, a written informed consent was obtained from the students after explaining the purpose of the study. They were informed that their participation is voluntary, and they can withdraw at any time. Confidentiality, privacy, and anonymity of the students and their responses were assured through the phases of the study.

Statistical Analysis:

Data were fed to the computer and analysed using IBM SPSS software package version 20.0. (Armonk, NY: IBM Corp) Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range (minimum and maximum), mean, standard deviation, median. Significance of the obtained results was judged at the 5% level. The used tests were:

1. **Chi-square test:** For categorical variables, to compare between different groups
2. **Monte Carlo correction:** Correction for chi-square when more than 20% of the cells have expected count less than 5
3. **Mann Whitney test:** For abnormally distributed quantitative variables, to compare between two studied groups

Results

Results will be divided into two parts. First, effectiveness in term of students' attitudes, then effectiveness in relation to students' achievement in midterm and final exams.

Table (1): Comparison between the Two Groups of Students enrolled in Anatomy and Physiology Course in terms of their General Learning Management Skills and Information Retention Ability

Q		Digital games (n = 50)		Paper-based games (n = 50)		U	p
		Mean ± SD.	Median	Mean ± SD.	Median		
I.	**General Learning Management Skills & Information Retention Ability**						
2	I could learn interesting new learning skills recently.	3.70 ± 0.46	4.0	3.04 ± 0.70	3.0	607.50*	<0.001*
10	I felt my learning experience was personalized.	3.54 ± 0.58	4.0	2.98 ± 0.68	3.0	709.00*	<0.001*
12	It was easy to receive immediate feedback.	3.72 ± 0.45	4.0	2.96 ± 0.60	3.0	480.00*	<0.001*
18	I could take better notes.	3.54 ± 0.65	4.0	3.10 ± 0.51	3.0	744.00*	<0.001*
19	It helps me studying for exams.	3.48 ± 0.50	3.0	2.98 ± 0.55	3.0	721.00*	<0.001*
22	It helps me recalling content during exams.	3.52 ± 0.50	4.0	3.10 ± 0.54	3.0	790.00*	<0.001*
24	It helps to emphasize the important points.	3.60 ± 0.49	4.0	3.12 ± 0.52	3.0	710.00*	<0.001*
	TOTAL	**3.59 ± 0.38**	**3.57**	**3.04 ± 0.32**	**3.0**	**350.00***	**<0.001***

U: Mann Whitney test   *p: p value for comparing between the studied groups*
*: Statistically significant at p ≤ 0.05   *SD: Standard deviation*

Table (2): Comparison between the Two Groups of Students enrolled in Anatomy and Physiology Course in terms of their Attentiveness and Motivation in Laboratory Session & Class Control

Q		Digital games (n = 50)		Paper-based games(n=50)		U	P
		Mean±SD	Median	Mean±SD	Median		
II.	**Attentiveness and Motivation in Laboratory Session & Class Control**						
15	It holds my attention till the end of the session.	3.52 ± 0.54	4.0	3.06 ± 0.51	3.0	736.50[*]	<0.001[*]
11	I felt having fun when performing laboratory missions.	3.60 ± 0.57	4.0	2.98 ± 0.62	3.0	626.00[*]	<0.001[*]
7	I felt interested in laboratory activities.	3.78 ± 0.42	4.0	2.92 ± 0.75	3.0	445.00[*]	<0.001[*]
16	It increases the likelihood of inappropriate behavior.	1.92 ± 1.01	2.0	2.26 ± 0.90	2.0	968.50[*]	0.041[*]
17	I prefer traditional lectures.	2.50 ± 1.11	3.0	2.36 ± 0.88	2.0	1135.50	0.412
21	I prefer such kind of learning activities in the laboratory over the ppt with audio, video, or text.	3.02 ± 0.98	3.0	3.08 ± 0.67	3.0	1236.50	0.920
23	I am less motivated to attend laboratory sessions when traditional approach is used.	1.98 ± 1.0	2.0	2.46 ± 0.91	2.50	900.50[*]	0.012[*]
25	I am so satisfied and feel motivated now.	3.54 ± 0.50	4.0	2.96 ± 0.45	3.0	606.00[*]	<0.001[*]
	TOTAL	**2.98 ± 0.29**	**2.88**	**2.76 ± 0.31**	**2.75**	714.00[*]	<0.001[*]

χ2: Chi square test   U: Mann Whitney test   SD: Standard deviation
*p: p value for comparing between the studied groups   *: Statistically significant at p ≤ 0.05*

Table (3): Comparison between the Two Groups of Students enrolled in Anatomy and Physiology Course in terms of their Course Content-Specific Related Attitudes

Q		Digital games (n = 50)		Paper-based games (n=50)		U	p
		Mean±SD	Median	Mean±SD	Median		
III.	**Course Content-Specific Related Attitudes**						
	I do not feel very competent in this course	2.16 ± 0.91	2.0	2.50 ± 0.76	2.0	960.50[*]	0.032[*]
8	I felt interested.	3.70 ± 0.51	4.0	3.20 ± 0.73	3.0	755.50[*]	<0.001[*]
1	I feel pressured.	2.52 ± 0.97	3.0	2.34 ± 0.75	2.0	1062.50	0.170
26	I hate attending Anatomy& Physiology lab.	2.72 ± 1.13	3.0	2.58 ± 0.81	3.0	1094.00	0.259
29	learning activities improved my understanding of the complexed content and concepts in anatomy and physiology.	3.50 ± 0.58	4.0	3.14 ± 0.53	3.0	843.00[*]	0.001[*]
33	Activities generated motivation for deeper knowledge.	3.66 ± 0.59	4.0	3.18 ± 0.48	3.0	655.50[*]	<0.001[*]
	TOTAL	**3.04±0.28**	**3.0**	**2.82±0.24**	**2.83**	**660.50[*]**	<0.001[*]

χ2: Chi square test   U: Mann Whitney test   SD: Standard deviation
*p: p value for comparing between the studied groups   *: Statistically significant at p ≤ 0.05*

Table (4): Comparison between the Two Groups of Students enrolled in Anatomy and Physiology Course in terms of their Professor-Related Attitudes

Q		Digital games (n = 50)		Paper-based games (n = 50)		U	p
		Mean±SD	Median	Mean±SD	Median		
IV.	**Professor-Related Attitudes**						
3	I have a feeling that my professor cares about me.	3.62 ± 0.49	4.0	3.10 ± 0.84	3.0	814.50*	0.001*
13	Learning at campus "in the faculty" is important to me.	3.56 ± 0.61	4.0	3.38 ± 0.60	3.0	1038.50	0.099
20	Professors who use such kind of learning activities are more organized during the lab. session.	3.28 ± 0.78	3.0	3.02 ± 0.65	3.0	963.00*	0.028*
	TOTAL	**3.49 ± 0.49**	**3.33**	**3.17 ± 0.50**	**3.17**	**827.50***	**0.003***

χ2: Chi square test   U: Mann Whitney test   SD: Standard deviation
p: p value for comparing between the studied groups   *: Statistically significant at p ≤ 0.05

Table (5): Comparison between the Two Groups of Students enrolled in Anatomy and Physiology Course in terms of their Self-Related Attitudes

Q		Digital games (n = 50)		Paper-based games (n = 50)		U	p
		Mean±SD	Median	Mean±SD	Median		
V.	**Self-Related Attitudes**						
4	I often do not feel very capable academically, esp. with this course.	2.62 ± 1.10	3.0	2.56 ± 0.81	3.0	1169.00	0.557
5	This course makes me satisfied with myself.	3.62 ± 0.49	4.0	2.94 ± 0.77	3.0	624.00*	<0.001*
9	I felt confident to use my mind during the lab.	3.54 ± 0.58	4.0	3.08 ± 0.53	3.0	738.50*	<0.001*
14	When exams and assignments are coming up, I worry a lot	2.14 ± 0.95	2.0	1.80 ± 0.73	2.0	1010.50	0.080
27	I feel lost because of these activities.	2.60 ± 1.03	3.0	2.70 ± 0.89	3.0	1222.00	0.836
28	Such activities increased my independence feelings.	3.46 ± 0.54	3.0	2.90 ± 0.61	3.0	691.50*	<0.001*
31	The learning experience empowered me to take control over my learning.	3.62 ± 0.49	4.0	2.90 ± 0.54	3.0	499.00*	<0.001*
30	Generally, this learning experience yielded feeling of stress and nervousness.	2.44 ± 1.01	3.0	2.48 ± 0.74	2.50	1239.00	0.936
32	This yielded a feeling of being unorganized and unstructured.	2.40 ± 1.07	3.0	2.40 ± 0.76	2.0	1203.00	0.731
6	Being taught in such a way, I felt I was in control of my learning process during lab. session.	3.64 ± 0.48	4.0	2.96 ± 0.60	3.0	560.00*	<0.001*
	TOTAL Self-related attitudes	**3.01 ± 0.41**	**2.90**	**2.67 ± 0.32**	**2.60**	**656.50***	**<0.001***
	Overall Score	**3.17±0.26**	**3.12**	2.84±0.25	2.85	402.50*	<0.001*
	% score	**72.31±8.63**	**70.59**	61.29±8.47	61.76		

χ2: Chi square test   U: Mann Whitney test   SD: Standard deviation
p: p value for comparing between the studied groups   *: Statistically significant at p ≤ 0.05

Table (6): Comparison between the Two Groups of Students enrolled in Anatomy and Physiology Course in terms of their Overall Course Satisfaction Level

Students' Overall Course Satisfaction Level Measured on 1 to 10 rating scale	Digital games (n = 50)		Paper-based games (n = 50)		Test of sig.	p
	No.	%	No.	%		
1	1	2.0	1	2.0	χ^2= 17.241[*]	^{MC}p= 0.013[*]
2	0	0.0	0	0.0		
3	1	2.0	1	2.0		
4	0	0.0	3	6.0		
5	0	0.0	5	10.0		
6	1	2.0	8	16.0		
7	10	20.0	9	18.0		
8	13	26.0	10	20.0		
9	6	12.0	4	8.0		
10	18	35.0	9	18.0		
Min. – Max. Mean ± SD. Median	1.0 – 10.0 8.36 ± 1.80 8.0		1.0 – 10.0 7.16 ± 2.08 7.0		U=790.0[*]	0.001[*]

$\chi2$: Chi square test   U: Mann Whitney test   SD: Standard deviation
p: p value for comparing between the studied groups   *: Statistically significant at $p \leq 0.05$

Table (7): Comparison between the Two Groups of Students enrolled in Anatomy and Physiology Course in terms of their achievement during the Midterms, Final exams and Over-all achievement.

	Digital games (n = 50)	Paper-based games (n = 50)	U	p
Midterm Exam:				
Min. – Max.	5.60 – 10.0	5.25 – 10.0	1183.00	0.642
Mean ± SD.	8.91 ± 1.01	8.94 ± 1.17		
Median	9.0	9.50		
Final Exam:				
Min. – Max.	5.0 – 10.0	3.60 – 10.0	761.500[*]	0.001[*]
Mean ± SD.	8.20 ± 1.10	6.99 ± 1.82		
Median	8.0	7.40		
Total				
Min. – Max.	12.0 – 20.0	10.55 – 20.0	938.50[*]	0.032[*]
Mean ± SD.	17.11 ± 1.83	15.92 ± 2.64		
Median	17.0	16.38		

U: Mann Whitney test   p: p value for comparing between the studied groups
SD: Standard deviation   *: Statistically significant at $p \leq 0.05$

Table (1): Is discussing students' reflection on their general learning management skills that they have acquired and their information retention abilities. It showed that students who have been practicing learning through mobile educational games rated themselves very high and the difference in their rating significantly differed than those who experienced learning through routine laboratory activities with U= 350.00; P≤ 0.001 with mean and standard deviation for both of them (3.59 ± 0.38), (3.04 ± 0.32) respectively. It was also so apparent that students of the digital group ratings were significantly very high than those of the control group at all related statement with P ≤ 0.001. Those statements like acquisition of new learning skills, having such a personalized learning experience that suited their learning style, receiving immediate feedback regarding mistakes, helping in making useful notes during lab. period, having training for exams that decreased exam tension, helping in recalling the material learnt, as well as putting emphasis on the important points in each lab. session have made such great differences among ratings of the digital group and routine activities group at P≤ 0.001.

Table (2): Is putting the light on students' reporting regarding their attentiveness throughout the lab. time

and their level of motivation as well as absence of disruptive behaviour and side talks, the current study revealed a very high significant difference at P≤ 0.001 and U= 714.00* for the favour of computer game-based learning group with Mean and standard deviation (2.98± 0.29) while for students experienced routine lab. activities were (2.76± 0.31). This high statistical difference resulted from very high significant difference also in ratings like attentiveness during lab. time, feeling sense of fun during such missions, and feeling interested. Even when students asked about their preferences, the digital group reported a moderately significant difference in disliking usual Presentations and routine activities than the other group at P≤0.05, with U= 900.50 and the mean and standard deviation for digital and control group equal (1.98 ± 1.0), (2.46 ± 0.91) respectively.

Students also taught by computer-games upheld a significantly low probability of displaying inappropriate class-room behaviour like side talks or getting involved in other internet activities other than the academic activities than those reported by the control group at P≤0.05 with U=968.50 with mean and standard deviation for both groups (1.92± 1.01), (2.26± 0.90) respectively.

Table (3): As regarding the students' reported attitudes towards the Anatomy and Physiology course after the use of each medium for learning, reveals a very high statistically significant difference between both groups for the favour of the digitally learnt group at P≤ 0.001 with U= 660.50 where the mean and standard deviation for the digital and control group were (3.04± 0.28) and (2.82± 0.24) respectively. As they significantly approved that they felt interested in studying such subject matter and that such kind of learning activities improved my understanding of the complexed content and concepts and they confirmed that such learning experience generated motivation for deeper knowledge about anatomy and physiology of the human body at P≤ 0.001. Moreover, Students with usual lab. activities reported that they do not feel very competent in this course with a moderately significant difference at P≤ 0.05 and with U= 960.50 where the mean and standard deviation for the control group as compared to the digital group equalled (2.50 ± 0.76) and (2.16 ± 0.91) respectively.

Table (4): In concern to the reported professor-related attitudes, shows that students who were experiencing learning through computer game-based learning displayed a statistically very high attitudes towards the faculty as compared to those who have been taught through the routine lab. activities which came significantly different at P≤0.05 with U= 827.50 and mean, standard deviation equalled (3.49 ± 0.49)

and (3.17 ± 0.50) respectively. The digital group confirmed that they feel caring from the side of the faculty and that they were much organized in instruction using such kind of digital medium than what reported with the other group.

Table (5): Moreover, illustrates that students in the digitally oriented group displayed and reported a very highly significant statistical differences in self-related attitudes as compared with the other group at P≤0.001 where the U=656.50, the mean and standard deviation were (3.01 ± 0.41), (2.67 ± 0.32) respectively. In this regard, digitally oriented group reflected high significant differences in self-satisfaction and self-confidence in using cognitive abilities during lab. sessions, increasing the feeling of independence and the feeling of empowerment to take control over own learning as well.

Generally, students that experienced learning through computer games showed very high significant difference in positive attitudes over those who were taught using routine lab. activities at P≤ 0.001, U= 402.50 with mean and standard deviation equalled (3.17±0.26) and (2.84±0.25) respectively.

Table (6): Illustrates that when students were asked about their overall satisfaction level from learning anatomy and physiology through digital game-based platforms, putting their satisfaction level on a scale ranging from 1 to 10, their responses differed significantly at P≤0.05 when using χ^2 and the value of χ^2= 17.241 as compared to those who were taught by the other routine laboratory activities. Table 6 also reveals that about 50% of the digitally oriented students as compared to only 25% of the control group who rated their level of satisfaction as 9-10 on the 10-point rating scale. Moreover, Mann Whitney test showed a very high significant difference at P≤ 0.001 in favour of the digital group as the mean and standard deviation was (8.36 ± 1.80) as compared to (7.16 ± 2.08) for the other group.

Table (7): The table above inferred that the digitally oriented group of participants in the study meet a varying degree of achievement level in comparison with the paper-based approach during the entire terms. Evidently, putting the light on the impact of both kinds of activities on students' cognitive achievement, the current study revealed on the short-term effect that there was no significant statistical difference, while on the long run, on the final exam, achievement of the digitally oriented group found to be varying significantly than the other group instructed through routine lab. activities at P≤ 0.001, U= 761.500 with mean and standard deviation (8.20 ± 1.10) and (6.99 ± 1.82) respectively. Generally, digital group achievement varied significantly in a positive way when compared with the control group at P≤ 0.05 with U= 938.50, mean and standard

deviation (17.11 ± 1.83) as compared to (15.92 ± 2.64) for the routine lab activities group.

Discussion
In fact, the use of digital games in health professions education was first used by Froebel in learning during the 19th century **(McCoy et al., 2016).** Shift from the traditional approach to integration of new technologies into the curriculum led to the evolution of pedagogy for both their preclinical and clinical medical training basically catering the needs of the internet generation **(Loftus, 2015).**

Indeed, the use of digital games in medical education is still in its infancy stage and there is still a dearth of rigorous studies that neither confirm nor refute its use as an effective teaching strategy **(Pettit et al., 2015).** Other studies have reported several benefits of digital game-based learning (DGBL) over the traditional approach **(Boeker et al., 2013).**

The current study showed how the application of digital-based approach helped in improving the learning management skills of the students which vigorously engages students in active learning as the modality gave students a concrete and real situation where the learner can analyse complexed real-life situations. In fact, in Australia, this approach provided an opportunity for first year Human Life Sciences (HLS) students to be active participants in their learning while simultaneously having fun and engaging experience. Hence, it was regarded as a vital pedagogical tool in the school's portfolio of teaching and learning resources among freshmen HLS students **(Nazeer et al., 2018).** In Saudi Arabia, the use of games like crossword puzzles also provided an active learning opportunity and helped develop critical thinking and better comprehension skills for human anatomy students **(Bigdeli & Kaufman, 2017).** Another more recent study in Saudi Arabia **(Elcokany et al., 2021)** proved also that computer-based case scenarios were highly accompanied by higher achievement and improved decision-making skills for nursing students. This came in line with the results of the current study to some extent, as the students in both groups showed no difference in their knowledge acquisition and achievement on the short run (in the seventh week), while at the end of the study- in the 15th week- students of the digital group showed much higher grades as compared to the routine laboratory activities group which differed significantly. Generally, the digital group achieved significant higher grades which means higher retention of knowledge than the control group.

However, few systematic reviews of studies on the use of games **(Yunyongying, 2014)** and simulations for health care education **(Akl et al., 2013)** reported mixed results as to its substantial learning effects **(Colbert & Chokshi, 2014 & Westfall et al., 2014).** On the other hand, games, mobile applications, and virtual patient simulations proved to be useful in medical education such as in promoting learning and engagement **(Tabatabai, 2020),** competitiveness and teamwork **(Mahali et al., 2016),** application of real-world situations, practicing clinical decision making **(Elcokany et al., 2021 & Evans et al., 2015),** provide timely feedback **(Boeker et al., 2013)** and help in recalling the studied material in both the classroom and laboratory sessions **(Gottlieb et al., 2013, Aburahma & Mohamed, 2015).**

The Kahoot gamification program, a widely used digital game for educational purposes, showed evidence in threading through collaborative team- and gamification-based learning in curriculum design of histology or other health professions. **Felszeghy et al. (2019)** confirmed that the students reported a high over-all satisfaction rate as exemplified by an increased motivation to learn, interest, collaboration, provided quick feedback and likewise helped overcome students' personal differences. This came congruent with the results of the present study which revealed that students in the mobile games group reported a highly significant difference in their acquisition of learning management skills and knowledge retainability as well as higher attentiveness and motivation to learning and less disruptive behaviours than those who taught through paper-based sketches, and anatomy diagrams, crossword puzzles as well as low fidelity mannequins. More importantly, their overall satisfaction rate was much more significant than the other group.

Digital games as a pedagogy were likewise known to be suitable for students with diverse learning styles **(Boctor, 2013).** To achieve this, the teachers need to ensure that the learners' personal characteristics are taken into consideration in the instructional game design. In fact, one of the items in the instrument states that" I felt my learning experience was personalized. It suits "my learning style" and I can learn by my own pace 'speed of learning, I can repeat tasks whenever I want (Item 10 under Part I. General Learning Management Skills & Information Retention Ability). This emphasizes the key points of using digital game-based as important modality that actively encourage students to engage in the subject. The students became interested in the laboratory activities as observed in the Item 7 both relates under Part II. Attentiveness and Motivation in Laboratory Session and Class Control as well as on the Course Content-Specific Related Attitudes. Other indicators showed the satisfaction of the students even they felt that their professor care for them and making them satisfied as well as the learning experience empowered students to take control of their learning.

Truly, the digital game-based approach is a better medium of learning. The use of gamification will be making waves on the communication scene to be implemented in many new ways for education, health, work, and other role in everyday activities **(Parisod, 2017).**

Studies have proved the potential of digital games to support learning in terms of conceptual understanding, information processing, skill practicing as well as engagement in decision making process **(Elcokany et al., 2021 & Clark et al., 2017).** Researchers also confirm that educational games and simulations displayed excellent results on the three domains of learning outcomes the cognitive, psychomotor as well as affective **(Vlachopoulos & Makri, 2017 & Chernikova et al., 2020).** This all comes parallel with the results of our current study as both achievement and the overall attitudes of digitally taught students using different applications like Kahoot, Quizlet, Quizalize, Quizizz uploaded on EdModo in form of mobile games were significantly higher than those who were taught using paper-based drawings, mannequins, sketches and diagrams with blanks as well as crossword activities.

While the unevenness of systematic evidence for games as learning tools was acknowledged by the National Research **Council (2011)**, several recent comparisons on the effectiveness of digital game-based learning and traditional pedagogy lack sound empirical evidence that made it difficult to generalize due to diversity in the measures used for assessing the outcome, variety of data collection methods and inconclusive or confusing discussion of results. **(All et al., 2014)**.

At Sweedu.com: Education Simplified (2020) it was mentioned that students become interested with digital-based as it provides students with unique facilities resulting to easier and faster study which are not available during traditional classes. This modality attracts students' interest and motivates them to opt for digital learning. Similarly, Motivation is one of the key factors affecting learners' success and performance, but this remains a challenge in maintaining students' motivation for teachers. In a review of studies conducted on pharmacy students **Aburahma, M. & Mohamed H. (2015)** it was highlighted that educational games foster less stressful environment which is conducive to learning and helping in collaboration among students and keep them interested and motivated. They added that anxiety always hinders learning and engagement. Even though, they illustrated that some students felt overwhelmed by learning how to play the game. In this regard, **Hartnett (2016)** illustrate that motivation in online learning is considered a complex phenomenon that is mostly affected by individual traits and specific contexts.

Regarding so, our study showed that digitally taught students reported highly significant positive feedback compared to the traditionally taught group as they confirmed that the digital games made them more interested, engaged and attentive in the lab with lessening the disruptive behaviours and side talks. A contradicting study on comparing traditional and eLearning modality found that there was no significant difference between students' behavioural engagement in traditional classroom and e-learning. But e-learning facilitated higher level learning better at aspects of innovative thinking and critical thinking **(Li et al., 2014)**.

In reporting for attitudes toward the anatomy and physiology course content after using the digital games, nursing students confirmed that those mobile digital games enhanced significantly deeper understanding and simplification of complex concepts and material in the course as compared to reports from traditionally taught group. They felt much competent and interested in Anatomy and Physiology of the human body than other students as the digital games conveyed the course material in a much more pleasant and interesting way which increased their attention, enhanced their motivation to learn anatomy and physiology of the human body and extensively exaggerated their intent to actively being engaged in activities during the lab sessions along the whole term. Concerning so, **Mese & Sevilen (2021)** stated in the pedagogical implications of their study that course content and materials should be engaging and meaningful so that students can maximize motivation and learning of such subject matter. In line with that **Elcokany et al., (2021)** delineated game-based learning as the one that attracts students' attention and enhances achievement much better than the traditional learning pedagogy.

Furthermore, this research showed that, participants using the digital based game approach felt caring attitude from the side of their professors and that this kind of pedagogy made it more organized during laboratory session than the other traditionally taught group. This may be due to the environment that the digital-based approach offers that is full of fun and enhancement of more engaging activities in the interactive learning environment. It was confirmed in literature that digital games are powerful social, technological and cultural force bringing a lot of innovative and positive changes with key features for the new generation. Research on digital games and serious games in education concluded that both games can serve as an educational tool boosting student's wellbeing and self-esteem to develop critical thinking, decision-making skills while

maintaining mental and psychological balance **(Anastasiadis et al., 2018, Elcokany et al., 2021).** With this view, the researcher analysed the situation that digital based approach made students' feel cared from their professors.

This research also showed that by using digital game-based approach the students felt much significant enhancement in their self-related attitudes as compared to the traditional pedagogy group. Students did the requested tasks with an intrinsic satisfaction that made them act to learn with joy and challenged themselves without thinking of the activity as a pressure. Feelings that were reported to be significantly enhanced as compared to the traditional group were genuineness, self-reliance, autonomy, self-satisfaction, self-confidence to use their minds during the lab as well as feeling empowered to take control over learning which are all considered as the main features and key principles of the digitally-based learning approach. This comes in line with **Perrotta et al. (2013) & Aburahma& Mohamed (2015).** Perhaps having control on the learning is frequently the most appealing factor contributing to the self-related attitude of the students over traditional learning. Unlike paper-based approach, digital game-based provides for more flexibility and empowerment over learning that is accompanied by students' accountability. Digital game -based learning is not just a game to play with but an act of designing interactive learning tasks that can gradually convey concepts and guide students to achieve learning goals. It is considered a teaching method that provide students a chance to explore different parts of the games as a form of learning to help them enhance their set of skills or achieve specific learning outcomes **(Spires, 2015). Erhel & Jamet (2013)** pointed out other dimensions that must be kept in mind in university teaching that the learning harvests which are learning satisfaction, feeling of achievement and learning preferences that measures teaching efficiency.

On the whole, the present research revealed that students were much more satisfied with the digital game -based learning as compared to the paper-based learning. This resulted from the flexibility given by such approach that allowed for more organized framework that enabled learners to gain knowledge as well as to acquire skills of learning management which something neglected in the traditional pedagogy where students' self-growth is not prioritized Online (Online Business School, n.d.). Parallel to such results were results of **El Kokany et al. (2021)** that revealed a significant overall satisfaction for nursing students on computer-based simulation than traditional approach.

The findings of the results in this experimental study provide important evidence for the potential benefits of utilizing digital game-based approach for learning since meeting learning outcomes has proven to be challenging in traditional classrooms.

Learning necessitates satisfaction to enable the students to continue their engagement to subject matters. Depending on the quality of design of the educational digital game, it can create and sustain the motivation, attention, interest and engagement in the moment of learning **(Clark et al., 2015).**

Conclusions:

This longitudinal experimental research has shown that mobile digitally-based educational games using different applications like Kahoot, Quizlet, Quizalize, Quizizz that their links were added to a digital class that created on EdModo significantly improves nursing students' learning as compared to the use of traditional laboratory learning tasks which were done on paper-based drawings, diagrams and mannequins to sketches and diagrams with blank instructions as well as crossword games. Moreover, this innovative approach to learning yields significantly positive feelings of reported attitudes in many areas like general management skills and information retention ability, attentiveness and motivation in laboratory sessions and class control. These added to significant positive feedback towards course content-specific related attitudes, professor-related attitudes, and self-related attitudes with a distinct high achievement as compared to the other group. As such, the findings of this study support further use of additional digital games in teaching Anatomy and Physiology material as such approach enhances the students' achievement as well as brings about high level of interest, motivation and attention throughout class or laboratory session which is upgrading the subject course.

Recommendations:

The results of such study give clue that digital games can be tested for their effectiveness in other subject matters and with students in different specialties all through the higher education.

References

- **Aburahma, M., & Mohamed, H. (2015):** REVIEW: Educational Games as a Teaching Tool in Pharmacy Curriculum. American Journal of Pharmaceutical Education, 79 (4) Article 59, 1-9. https://www.ajpe.org/content/ajpe/79/4/59.full.pdf.
- **Akl, E., Sackett, K., Erdley, W., Mustafa, R., Fiander, M., Gabriel, C., & Schünemann, H. (2013):** Educational games for health professionals. The Cochrane database of systematic reviews, (1),

CD006411.
https://pubmed.ncbi.nlm.nih.gov/23440807/.

▪ **All, A., Castellar, E., & Looy, J. (2014):** Measuring Effectiveness in Digital Game-Based Learning: A Methodological Review. International Journal of Serious Games, 1(2), 3–20. https://journal.seriousgamessociety.org/~serious/index.php/IJSG/article/view/18/pdf_55.

▪ **Anastasiadis, T., Lampropoulos G., & Siakas, K. (2018):** Digital Game-based Learning and Serious Games in Education. International Journal of Advances in Scientific Research and Engineering, 4 (12), 139-144. 10.31695/IJASRE.2018.33016. https://www.researchgate.net/publication/329921232_Digital_Game-based_Learning_and_Serious_Games_in_Education

▪ **Bigdeli, S., & Kaufman, D. (2017):** Digital games in medical education: Key terms, concepts, and definitions. Med J Islam Repub Iran, 31(1), 1-7. https://mjiri.iums.ac.ir/article-1-3952-en.pdf.

▪ **Boctor, L. (2013):** Active-learning strategies: The use of a game to reinforce learning in nursing education. A case study. Nurse Educat pract., 13(2),96-100.

▪ **Boeker, M., Andel, P., Vach, W., & Frankenschmidt, A. (2013):** Game-based e-learning is more effective than a conventional instructional method: A randomized controlled trial with third-year medical students. PlOS ONE, 8(12): e82328. DOI:10.1371/journal.pone.0082328.

▪ **Brown, C., Comunale, M., Wigdahl, B., & Urdaneta-Hartmann, S. (2018):** Current climate for digital game-based learning of science in further and higher education. *FEMS Microbiology Letters*, *365*(21). https://doi.org/10.1093/femsle/fny237.

▪ **Chernikova, O., Heitzmann, N., Stadler, M., Holzberger, D., Seidel, T., & Fischer, F. (2020):** Simulation-Based Learning in Higher Education: A Meta-Analysis. Review of Educational Research, 90 (4), 499–541. DOI:https://doi.org/10.3102/0034654320933544.

▪ **Clark, D., Sengupta, P., Brady, C., Garza, M., & Killingsworth, S. (2015):** Disciplinary integration of digital games for science learning. International Journal of STEM Education, 2(2), 1-21. https://stemeducationjournal.springeropen.com/track/pdf/10.1186/s40594-014-0014-4.pdf.

▪ **Colbert, J., & Chokshi, D.A. (2014):** Technology in medical education—Osler meets Watson. J Gen Intern Med., 29(12),1584-5. DOI: 10.1007/s11606-014-2975-x.

▪ **Crawford, J., Butler-Henderson, K., Rudolph, J., Malkawi, B., Glowatz, M., Burton, R., Magni P., & Lam, S. (2020):** COVID-19: 20 countries' higher education intra-period digital pedagogy *responses.* J. Appl. Learn. Teach. 3(1), 1–20.

https://journals.sfu.ca/jalt/index.php/jalt/article/view/191.

▪ **Dichev, C., & Dicheva, D. (2017):** Gamifying education: what is known, what is believed and what remains uncertain: a critical review. International Journal of Educational Technology in Higher Education, 14(9), 1–36. https://doi.org/10.1186/s41239-017-0042-5.

▪ **Douglas B., Tanner-Smith, E., Hostetler, A., Fradkin, A., & Polikov V. (2018):** Substantial Integration of Typical Educational Games Into Extended Curricula, Journal of the Learning Sciences, 27:2, 265-318, DOI: 10.1080/10508406.2017.1333431.

▪ **Elcokany, N.M., Abdelhafez, A.I., Sharaby, V.M., & Belal, S. (2021):** Use of computer-based scenarios for clinical teaching: Impact on nursing students' decision-making skills. MDPI: Healthcare, 9(9): 1228. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8471097/pdf/healthcare-09-01228.pdf.

▪ **Erhel, S., & Jamet, E. (2013):** Digital game-based learning: Impact of instructions and feedback on motivation and learning effectiveness. Computers & Education, 67,156-167. https://www.academia.edu/24661221/Digital_game_based_learning_Impact_of_instructions_and_feedback_on_motivation_and_learning_effectiveness.

▪ **Evans, K.H., Daines, W., Tsui, J., Strehlow, M., Maggio, P., & Shieh, L. (2015):** Septris: a novel, mobile, online, simulation game that improves sepsis recognition and management. Academic medicine : journal of the Association of American Medical Colleges, 90(2), 180-4. https://doi.org/10.1097/ACM.0000000000000611.

▪ **Felszeghy, S., Pasonen-Seppänen, S., & Koskela, A. (2019):** Using online game-based platforms to improve student performance and engagement in histology teaching. BMC Med Educ, 19, 273. https://doi.org/10.1186/s12909-019-1701-0.

▪ **Gottlieb, R., Vervoorn, J.M., & Buchanan, J. (2013):** Simulation in Dentistry and Oral Health. In: Levine, A.I., DeMaria, S., Schwartz, A.D., Sim, A.J. (eds) The Comprehensive Textbook of Healthcare Simulation. Springer, New York, NY. (pp. 329-340). https://doi.org/10.1007/978-1-4614-5993-4_21,

▪ **Hartnett, M. (2016):** The Importance of Motivation in Online Learning. In: Motivation in Online Education. Springer, Singapore. Retrieved from: https://www.researchgate.net/publication/315033704_The_Importance_of_Motivation_in_Online_Learning.

▪ **Hill, R., & Nassrallah, Z. (2018):** A Game-Based Approach to Teaching and Learning Anatomy of the

Liver and Portal Venous System. MedEdPORTAL: The Journal of Teaching and Learning Resources, 14, 1-7. https://www.mededportal.org/doi/pdf/10.15766/mep_2374-8265.10696.

Huizenga, J., Ten Dam, G., Voogt, J., & Admiraal, W. (2017): Teacher perceptions of the value of game-based learning in secondary education. Computers and Education, 110, 105-115. https://doi.org/10.1016/j.compedu.2017.03.008.

Johnsen, H., Fossum, M., Vivekananda-Schmidt, P., Fruhling, A., & Slettebø, Å. (2018): Developing a Serious Game for Nurse Education. Journal of Gerontological Nursing, 44(1), 15–19. https://doi.org/10.3928/00989134-20171213-05.

Kamnardsiri, T., Hongsit L., Khuwuthyakorn, P., & Wongta, N. (2017): The Effectiveness of the Game-Based Learning System for the Improvement of American Sign Language using Kinect. The Electronic Journal of e-Learning, 15 (4), 283-296. https://files.eric.ed.gov/fulltext/EJ1154946.pdf.

Kober, S., Wood, G., Kiili, K., Moeller, K., & Ninaus, M. (2020): Game-based learning environments affect frontal brain activity. PlOS ONE, 15(11), e0242573. https://doi.org/10.1371/journal.pone.0242573.

Loftus, S. (2015): Understanding Integration in Medical Education. Med.Sci.Educ. 25, 357–360. https://doi.org/10.1007/s40670-015-0152-4.

Lorenzo-Alvarez, R., Rudolphi-Solero, T., Ruiz-Gomez, M., & Sendra-Portero, F. (2020): Game-Based Learning in Virtual Worlds: A Multi-user Online Game for Medical Undergraduate Radiology Education within Second Life. Anatomical sciences education, 13(5), 602–617. https://doi.org/10.1002/ase.1927.

Li, F., Qi, J., Wang, G., & Wang, X. (2014): Traditional Classroom vs E-learning in Higher Education: Difference between Students' Behavioral Engagement. International Journal of Emerging Technologies in Learning, 9(2), 48–51. https://doi.org/10.3991/ijet.v9i2.3268.

Lu, C., Wu, S., Shu, Y., & Yeh, M. (2018): Applying Game-Based Learning in Nursing Education: Empathy Board Game Learning. The Journal of Nursing, 65(1), 96–103. https://doi.org/10.6224/JN.201802_65(1).13.

Mahali, M., Jamaluddin, J., Din, N., Faizan, A., Abd-Jabar, F., Fadzillah, N., Fadzillah, M., & Ahmad, M. (2016): The Effects of Digital Games on Student's Learning Experience: A Review of Literature. Research Gate. https://www.researchgate.net/publication/318361620_The_Effects_of_Digital_Games_on_Student's_Learning_Experience_A_Review_of_Literature/citations.

Mayer R. (2019): Computer Games in Education. Annual review of psychology, 70, 531–549. https://doi.org/10.1146/annurev-psych-010418-102744.

McCoy, L., Lewis, J., & Dalton D. (2016): Gamification and Multimedia for Medical Education: A Landscape Review. The Journal of the American Osteopathic Association January, 116 (1), 22-34. https://www.researchgate.net/publication/290174716_Gamification_and_Multimedia_for_Medical_Education_A_Landscape_Review.

Meşe, E., & Sevilen, Ç. (2021): Factors influencing EFL students' motivation in online learning: A qualitative case study. Journal of Educational Technology & Online Learning, 4(1), 11-22. Retrieved from https://files.eric.ed.gov/fulltext/EJ1286748.pdf.

National Research Council. (2011): Learning Science Through Computer Games and Simulations. Washington, DC: The National Academies Press. doi:10.17226.

Nazeer, M., Razia, S., Muzammil, A., Rehan, A., Rasheed, H., & Sreekanth, T. (2018): Crossword Puzzles as an Active Learning Mode for Student Directed Learning in Anatomy Teaching: Medical Undergraduate Perceptions. International Journal of Medical Research & Health Sciences, 7(10): 12-19.

Ødegaard, N., Myrhaug, H., Dahl-Michelsen, T., & Røe, Y. (2021): Digital learning designs in physiotherapy education: A systematic review and meta-analysis. *BMC medical education*, *21*(1), 48. https://doi.org/10.1186/s12909-020-02483-w.

Online Business School. (n.d.). How the flexibility of online learning is helping it gain more popularity. https://www.onlinebusinessschool.com/how-the-flexibility-of-online-learning-is-helping-online-learning/.

Parisod, H. (2017): Healthy Games: Games as a method to promote health. http://www.empowerkids.eu/sites/default/files/healthygames_heidiparisod.pdf.

Perrotta, C., Featherstone, G., Aston, H., & Houghton, E. (2013): Game-based Learning: Latest Evidence and Future Directions (NFER Research Programme: Innovation in Education). Slough: NFER. https://www.nfer.ac.uk/publications/GAME01/GAME01.pdf.

Pettit, R., McCoy, L., Kinney, M., & Schwartz, F. (2015): Student perceptions of gamified audience response system interactions in large group lectures and via lecture capture technology. BMC Med educat,15(1), 92.

Radanliev, P., De Roure, D., Walton, R., Van Kleek, M., Montalvo, R., Santos, O., Maddox, L.,

& Cannady, S. (2020): COVID-19 what have we learned? The rise of social machines and connected devices in pandemic management following the concepts of predictive, preventive and personalized medicine. EPMA Journal, 11(3), 311–332. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7391030/

▪ **Rodríguez-Almagro, J., Prado-Laguna, M., Hernández-Martínez, A., Monzón-Ferrer, A., Muñoz-Camargo, J., & Martín-Lopez, M. (2021):** The Impact on Nursing Students of Creating Audio-visual Material through Digital Storytelling as a Teaching Method. International journal of environmental research and public health, 18 (2), 694. https://doi.org/10.3390/ijerph18020694.

▪ **Rüth, M., & Kaspar, K. (2021):** Commercial Video Games in School Teaching: Two Mixed Methods Case Studies on Students' Reflection Processes. Frontiers in psychology, 11, 594013. https://doi.org/10.3389/fpsyg.2020.594013.

▪ **Sailer, M., Hense, J., Mandl, H., & Klevers, M. (2017):** Fostering development of work competencies. In Mulder, M. (Ed.). Competence-based vocational and professional education: Bridging the world of work and education. Cham: Springer. 795–818. https://doi.org/10.1007/978-3-319-41713-4_37.

▪ **Sailer, M., & Homner, L. (2020):** The Gamification of Learning: a Meta-analysis. Educ Psychol Rev, 32, 77–112. https://doi.org/10.1007/s10648-019-09498-w.

▪ **Solís de Ovando, A., Rodríguez, A., & Hullin, C. (2018):** Digital Game-Based Learning: A Didactic Experience in the Pre-Degree Nursing Career. Studies in health technology and informatics, 250, 88.

▪ **Spires, H.A. (2015):** Digital Game-Based Learning: What's Literacy Got to Do With It?. Journal of Adolescent& Adult Literacy, 59 (2), 125– 130. doi: 10.1002/jaal.424.

▪ **Sweedu.com: Education Simplified. (2020):** Are students really interested in online class. https://sweedu.com/blog/are-students-really-interested-in-online-classes/ .

▪ **Tabatabai, S. (2020).** Simulations and Virtual Learning Supporting Clinical Education During the COVID 19 Pandemic. Advances in medical education and practice, 11, 513–516. https://doi.org/10.2147/AMEP.S257750.

▪ **Ulrica, L., Kiana, K., Susanne, J., & Per-A, S. (2021):** Nursing students' experiences of a pedagogical transition from campus learning to distance learning using digital tools. BMC Nurs. 20-23. doi: 10.1186/s12912-021-00542-1.

▪ **UNESCO. (2020):** Digital higher education. https://en.unesco.org/themes/higher-education. Accessed 12 January 2022.

▪ **Vlachopoulos, D., & Makri, A. (2017):.** The effect of games and simulations on higher education: a systematic literature review. Int J Educ Technol High Educ., 14, 22. https://doi.org/10.1186/s41239-017-0062-1.

▪ **Vladova, G., Ullrich, A., Bender, B., & Gronau, N. (2021):** Students' Acceptance of Technology-Mediated Teaching- How It Was Influenced During the COVID-19 Pandemic in 2020: A Study from Germany. Frontiers in psychology, 12, 636086. https://doi.org/10.3389/fpsyg.2021.636086.

▪ **Westfall, A.O., Nevin, C.R., Rodriguez, J.M., Dempsey, D.M., Cherrington, A., Roy, B., Patel, M., & Willig, J.H. (2014):** Gamification as a tool for enhancing graduate medical education. Postgrad Med J, 1(90), 685- 93. https://pmj.bmj.com/content/postgradmedj/90/1070/685.full.pdf.

▪ **Yunyongying, P. (2014):** Gamification: Implications for curricular design. Journal of graduate medical education, 6(3):410-2. DOI: http://dx.doi.org/10.4300/JGME-D-13-00406.