Are educational games more effective than traditional teaching for promoting learning in medical and dental undergraduates?

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Abstract

Objective: This evidence-based review aims to explore whether educational games are effective in medical and dental undergraduates.

Materials and methods: This review conducted a narrative synthesis using the ESRC method. Medline, Embase, and SCOPUS databases were searched using inclusion and exclusion criteria during the period of 1st January 1980 - 28th February 2013. The quality of papers was assessed using the critical appraisal tool by CASP and 2010 CONSORT guidelines. The strength of evidences was assessed using EPPI and GRADE approaches.

Results: A total of 391 citations were founded from the search strategy. However, after the processes of screening and eligibility assessment, two randomised controlled trials were included for this review. The first study was conducted in medical undergraduates while the second one was performed in dental undergraduates. Both studies found no significant difference in knowledge improvement after the immediate post-test. Retention of knowledge was investigated only in the first study (medical undergraduates), and it was found that the game group performed better. Only the second study (dental undergraduates) also explored the practical skill and found that there was no significant difference between two groups. Regarding the satisfaction measurement, students had positive attitudes towards the use of educational games in both studies.

Conclusion: Although education games are not significantly different from traditional education in the knowledge improvement, there should be an application of educational games in medical and dental education, as educational games can motivate and engage students. However, further studies are required to evaluate the effectiveness of the use of educational games in medical and dental undergraduates.

Key words: Dental education, Educational games, Evidence-based review, Games, Medical education, Undergraduates

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Background

Learning characteristics of students have changed. Students are now digital natives with 21st century skills[1]. Therefore, students' expectation of technology in education has risen[2]. Educational games can be applied to make traditional education more motivating and interesting[3], and seem to be successfully implemented in higher education[4]. However, the use of educational games in healthcare education is still unclear. This review is designed to explore whether educational games are effective in medical and dental education.

Searching the Cochrane Review database found reviews regarding using educational games in qualified healthcare professionals. However, no reviews examining educational games in healthcare undergraduates were available. This is an important point, as different generations may have different preferences towards the use of games in education.

A question was formulated using PICO to ensure the question would be an answerable research question and guide an effective search of the literature[5], as 'Are educational games more effective than traditional teaching for promoting learning in medical and dental undergraduates?'.

Materials and methods

A narrative synthesis in this review was conducted using the ESRC method, which can be appropriately used with the question regarding the effectiveness of the intervention, and it is not necessary to be used by systemic review experts[6].

Search strategy

To perform the facets analysis, the four components of the question derived from the PICO design formed the index terms (table 1 shaded). The Boolean operator 'OR' was used to combined terms within each facet, while 'AND' was used to combine the facets. Truncation ($) was used to make the search more sensitive.

Initial searches using the above criteria generated very low number of papers. Therefore, the "intervention" term was reduced to only 'game$' to increase sensitivity. Moreover, the 'comparison' component was not included due to the same reason. The following databases (Medline, Embase, and SCOPUS) were searched during the period of 1st January 1980-28th February 2013.

The inclusion and exclusion criteria were set to screen literature (table 2).

Table 1 Search terms used in Medline, Embase, and SCOPUS databases.

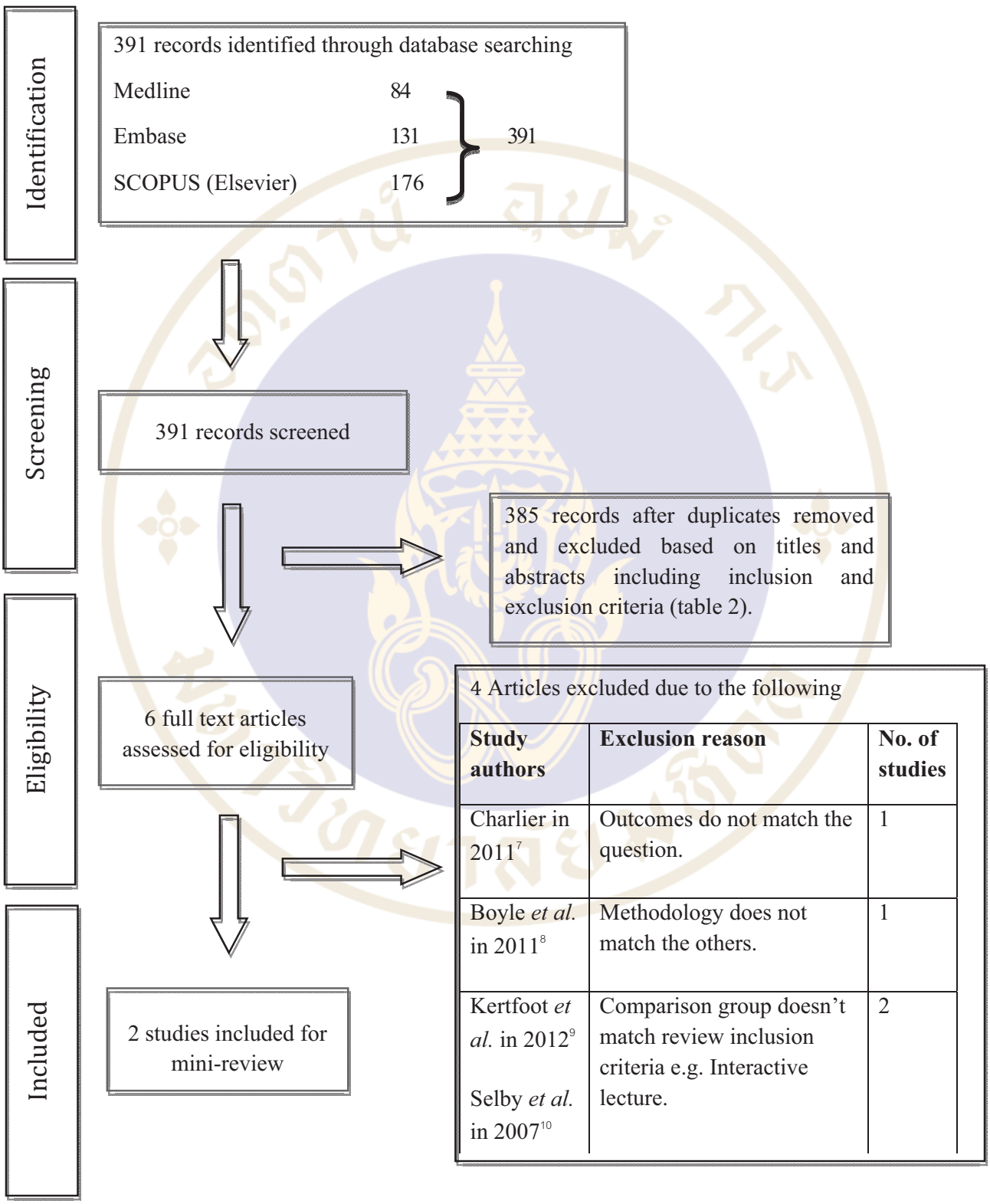
Population		Intervention	Comparison	Outcome
Medical and dental undergraduates		Educational games	Traditional teaching	Promoting learning
Medical Dental	Undergraduate$ Student$ Learner$	Educational game$ Serious game$ Training game$	Traditional teaching Lecture Passive learning	Knowledge Skills Competencies Performances

Table 2 Inclusion/Exclusion criteria.

Inclusion criteria	Exclusion criteria
• Primary studies • RCT • Undergraduate training • Comparable outcome	• Systemic review • Graduated or postgraduate training • Non-English literature

Literature identified

The demonstrated search strategy found 391 citations. After screening, 6 potentially eligible papers were identified to assess the full text. Afterwards, 2 papers were chosen for mini-review, as the following diagram.



4 Articles excluded due to the following

Study authors	Exclusion reason	No. of studies
Charlier in 2011[7]	Outcomes do not match the question.	1
Boyle *et al.* in 2011[8]	Methodology does not match the others.	1
Kertfoot *et al.* in 2012[9] Selby *et al.* in 2007[10]	Comparison group doesn't match review inclusion criteria e.g. Interactive lecture.	2

There is some literature regarding educational games in this field. However, most of them are systemic review or observation design. Moreover, some RCT studies have different outcomes or research methods. Finally, two studies were selected to answer this question:

1. Comparison of jeopardy game format versus traditional lecture format as a teaching methodology in medical education, studied by Khan *et al.* in 2011[11]

2. Development and Evaluation of an Interactive Dental Video Game to Teach Dentin Bonding, studied by Amer *et al.* in 2011[12]

Developing a preliminary synthesis

Both studies were chosen, because of their appropriate RCT design with relevant outcomes. The critical appraisal tool by Critical Appraisal Skills Programme will be used to assess the studies for quality[13]. The purpose of both studies was to find effectiveness of educational games using pre-test and post-test comparing with passive lecture including students' attitudes towards educational games. However, there were some different outcomes, as the first paper additionally explores the retention of knowledge while the second paper evaluates the practical skill, which are important performances for the students.

During preliminary synthesis, quality of the report was assessed by using 2010 CONSORT guidelines, which is improved in wording and clarity from 2001 version[14]. Each item will score 1 if it is reported and 0 if not. According to Péron *et al.*[15], 27 items were chosen from the guideline, and mean of overall quality score from 357 studies regarding oncology was 19.3. Both papers were evaluated against applicable items in the guideline modified by Péron *et al.*[15]. Although scores of both papers (table 3) are less than the mentioned score, both studies still have sufficient quality because some points are rarely found in educational studies such as blinding and adverse event classification.

Both studies were examined in detail, and key features were described and compared as shown in table 4.

Exploring relationship within and between studies

Knowledge measurement

Both studies employed pre-test and post-test to evaluate student's knowledge. There was no significant difference between two groups in the immediate post-test. However, Khan *et al.*[11] assigned post-test II, 2 months after post-test I, to assess retention of knowledge, and found that post-test II score in intervention group was significantly higher.

Satisfaction measurement

The 5-point Likert scale questionnaires were assigned to explore satisfaction towards learning styles. However, there is a different point that Khan *et al*. employed the satisfaction survey in both groups[11], while Amer *et al.* surveyed only in the intervention group. Both studies showed that students have positive attitudes towards educational games[12]. The results are calculated as average scores for simple presentation (table 6).

Practical skill measurement

According to Amer *et al.*, the practical examination regarding shear bond strength was assigned to compare practical skill using the Wilcoxon rank-sum test[12]. The result showed no significant difference between two groups.

Table 3 Quality reporting assessment.

Study	Khan et al.[11]	Amer et al.[12]
Points of Applicable (27 items)	18	15

Table 4 Important features of the included studies

Study name / Elements	Khan et al.[11]	Amer et al.[12]
Study type	RCT	RCT
Evidence level	1-	1-
Sample size	82	80
Population	Fifth-year medical students	First year dental students
Intervention	Jeopardy game format	Computer game
Comparison	Didactic lecture format	Clinical video
Primary outcome	Knowledge	Knowledge
Secondary outcome	Satisfaction Retention of knowledge	Attitudes (intervention group) Practical skills
Outcome measure value	Mean of Post-test score Mean of Likert scale	Mean of Post-test score Mean of Likert scale Shear bond strength
Conclusion	The game is as effective as lecture in the immediate post-test. The game is significantly better for the retention of knowledge (p=0.01). The game format is preferred than lecture format.	The game is as effective as the clinical video in the post-test. The responses tended to be very favourable to the use of the interactive video game. There is no difference in shear bond strength measures between two groups.

Table 5 Effect measure form pre-test and post-test

Studies / Outcomes		Khan *et al.*[11]	Amer *et al.*[12]	
Pre-test score	C	Mean=10.2	Median=7, Mean=6.27, SD=1.48	
	I	Mean=10.9	Median=6, Mean=6.49, SD=1.50	
	P	Not significant	Not significant	
Post-test I score	C	Mean=17.7	Median=8, Mean=8.34, SD=1.46	
	I	Mean=18	Median=8, Mean=8.03, SD=1.38	
	P	Not significant	Not significant	
Post-test II score	C	Mean=13.6	Not compared	
	I	Mean=16.6		
	P	p = 0.01		
	CI	-3.447-0.455		
Comparison of mean pre-test and post-test I score	C	CI: 6.731-8.243 t: 19.984, p < 0.000	Mean=2.07 SD=1.74	Not compared
	I	CI: 6.433-7.714 t: 22.314, p < 0.000	Mean=1.54 SD=1.54	
Comparison of mean post-test I and post-test II score	C	CI: 2.201-3.750 t: 7.763, p < 0.000	Not compared	
	I	Not significant		

Note: I: Intervention, C: Control, P: P value, CI: 95% Confidence Intervals

Table 6 Effect measure from satisfactory survey

Studies / Group	Khan et al.[11] N = 41 (each group)	Amer et al.[12] N = 35
Control group	Mean = 2.44 ± 0.36	Not provided
Experimental group	Mean = 4.61 ± 0.26 *	Mean = 4.16 ± 0.55

Note: 1 = strongly disagree to 5 = strongly agree

** = p < 0.001 compared to control*

Table 7 Effect measure form shear bond strength testing

Group / Study	Control group			Intervention group			P-value
	Sample size	MPa (mean)	MPa (median)	Sample size	MPa (mean)	MPa (median)	
Amer *et al.*[12]	41	13.45	12.6	36	13.41	12.9	Not significant (P=0.97)

Note: MPa = Megapascals

Clinical significance

For the study of Khan *et al.*[11], 95% confidence interval (CI) can be used to present clinical significance[16] and support the point regarding retention of knowledge (table 8). According to 95%CI, post-test I scores were significantly higher than pre-test scores in both groups. However, post-test II score significantly dropped in the control group, while it did not drop in the intervention group.

Regarding satisfaction survey from the same study, the students prefer game rather than lecture format (table 9).

Due to the non-parametric data in the study of Amer *et al.*[12], minimum, maximum, and median of scores are used to present clinical significance in the shear bond strength test (table 10). It seems that there is no difference between two groups.

Assessing the robustness of the synthesis

To assess the strength of evidence, EPPI approach was used as guidance to consider trustworthiness, appropriateness, and relevance[6]. In addition, GRADE approach was also used to assess the quality of evidence[17], as presented in table 11. Although both studies assigned RCTs as study design classified as high standard, there were some biases, which can reduce quality of studies. For example, regarding the retention of knowledge, the post-test II was set 2 months after the post-test I. Therefore, the students might obtain knowledge from other academic sources during this period. Moreover, the satisfaction questionnaires from both studies are quite positive. Thus, the outcomes

Table 8 Comparison of mean pre-test, post-test I, and post-test II score

Group	Comparison of mean pre-test and post-test I score	Comparison of mean post-test I and post-test II score
Control group	95%CI: 6.731-8.243	95%CI: 2.201-3.750
Intervention group	95%CI: 6.433-7.714	Not significant
Comparison of post-test II scores between the 2 groups	95%CI: -3.447-0.455	

might be over positive because the students tend to respond to the questionnaire positively, which is supported by Boynton and Greenhalgh[18].

The heterogeneity can be seen in table 4. Although one study compared jeopardy game to traditional lecture while the other compared interactive video game to clinical video, video can be used as a control group like lecture because both of them are passive learning. Consequently, they do not affect the strength of evidence.

Discussion

According to pre-test and post-test, educational games are as effective as traditional learning. This does not mean that educational games should not be applied to educational system. This notion is supported by the satisfaction survey undertaken by both studies. Michael and Chen suggest that the primary objective of educational games is not entertainment, but it does not mean they are not enjoyable[19]. Moreover, educational games are better for retention of knowledge, which is supported by Blakely *et al.* [20]. However, regardless of this positive perception of educational games, students strongly opposed the complete replacement of lectures by games[12]. Therefore, although educational games should be developed and deployed, it is to ascertain their place in the curricula and determine what part they play in replacing or supplementing lectures.

Limitation and recommendation

Despite popularity of educational games, there is a scarcity of RCT studies in undergraduate medical and dental education, resulting in difficulties to find high quality RCT studies. Therefore, more high quality research is needed in this field.

Table 9 Comparison of satisfactory survey

Questionnaire	Game format (Mean ± SD)	Lecture format (Mean ± SD)	Comparison
This educational format stimulates good faculty-student interaction	4.75 ± 0.435	2.51 ± 1.143	CI: 1.86 - 2.62
This educational format stimulates good student-student interaction	4.60 ± 0.666	1.85 ± 0.358	CI: 2.52-2.991
This educational format stimulates your interest and keeps you engaged in the class content	4.80 ± 0.401	2.39 ± 1.30	CI: 1.991-2.838
This educational format was enjoyable and full of fun	4.73 ± 0.449	2.63 ± 1.019	CI: 1.752-2.44
This educational format is an appropriate method of teaching	4.17 ± 0.77	2.80 ± 1.28	CI: 0.899-1.833

Note: 1 = strongly disagree to 5 = strongly agree
CI = 95% confidence interval

Table 10 Comparison of shear bond strength test

Group	Minimum	Median	Maximum
Control group	0 MPa	12.6 MPa	35.6 MPa
Intervention group	0 MPa	12.9 MPa	37.2 MPa

Note: MPa = Megapascals

Table 11 Summary of the strength of evidence

Study characteristics					Quality assessment				Summary of finding	
No. of study	Design	No. of samples	Outcome	Limitation	Inconsistency	Indirectness	Imprecision	Other consideration	Outcome	Quality
2	RCT	C:I 1. 41:41 2. 41:37	Knowledge	No limitation	No serious inconsistency	No indirectness	Precise	-	Educational games are as effective as traditional learning.	High
1	RCT	C:I 41:41	Retention of knowledge	Students might obtain knowledge from other academic sources during this period.	No inconsistency	No indirectness	Imprecise (-1): Only one study	-	Educational games are more effective than traditional learning.	Moderate
1	RCT	C:I 41:37	Shear bond strength test	The results might be affected from inexperience of students. (-1)	No serious inconsistency	No indirectness	Imprecise (-1): Only one study	-	Educational games are as effective as traditional learning.	Low
1	RCT	C:I 41:41	Satisfaction	No limitation	No serious inconsistency	No indirectness	Imprecise (-1): Only one study	-	Educational games are preferred than traditional learning.	Moderate
1	Cohort	35	Satisfaction	Questionnaires were not evaluated for validity and reliability before using. (-1)	-	No indirectness	Imprecise (-1): Only one study	Questions are quite positive.	Students tend to be very favourable to the use of educational games.	Very low

Note: C = Control group, I = Intervention group

In conclusion, educational games are as effective as traditional learning in knowledge improvement; they should be applied to medical and dental educational systems due to the characteristics of games. Educational games encourage students to interactively learn with their interests and have more retention of learning. However, further research in this field will be essential to support the use of educational games. Furthermore, more genres of outcomes should be explored to support the use of educational games. Together with quality of the game and research underpinning their use, the quantity of educational games to be used in medical and dental education needs to be examined to determine the optimal balance of games and traditional formats of learning.

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