

# Research on the impact of educational games on learning achievements from the perspective of learning science

Shuai ZHANG<sup>1</sup>, Hong LI<sup>2</sup>

1. Educational Technology, School of Information Science and Technology, Yunnan Normal University, Kunming 650500, China

2. Yunnan Normal University, Kunming 650500, China

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**Abstract:** This paper reviews the impact of educational games on learning outcomes from a learning science perspective. Using literature review, quasi-experiments, and meta-analysis, it finds educational games moderately enhance learning, particularly in primary education and practical knowledge. However, challenges like a lack of long-term studies, design limitations, balance issues, content alignment, and evaluation methods are noted. Recommendations include long-term studies, improved design, balanced content, curriculum integration, and comprehensive evaluation are proposed. Educational games have potential, but further research is needed to optimize their educational use.

**Key words:** learning science; educational games; learning outcomes

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## 1 Reason for choosing the topic

In the digital era, educational games have gained attention as an innovative teaching tool. Combining fun with education, they boost student engagement, interest, and cognitive skill development. However, the mechanisms behind their impact on learning remain unclear. By integrating learning sciences, which combine cognitive psychology, education, and neuroscience, this research aims to reveal how educational games influence learning outcomes. Understanding this impact is crucial for driving educational innovation and improving teaching quality.

## 2 Research status

The connection between games and education has always existed [1]. Since the emergence of educational games in the 1960s, they have progressed from the initial stage to the current flourishing phase [2]. Their potential as a force for educational reform has sparked widespread discussion among scholars. Early researchers initially studied abroad with the aim of applying the motivational aspects of video games to education to improve student learning outcomes [3]. With the advancement of technology and the spread of "edutainment" ideas, educational games gained broader attention [4]. In the new century, Western scholars like Squire (2003) and Prensky (2006) recognized the value of educational games, emphasizing their role in teaching 21st-century skills. Gee (2007) found that good educational games promote deep learning.

Research on the impact of educational games has produced three main conclusions: ① Educational games can

enhance learning outcomes [5][6]; ② They have no significant effect [7][8]; ③ They can have a negative impact [9]. For instance, Smith et al. (2013) found through quasi-experimental design that students using educational games for learning English vocabulary scored significantly higher than those using traditional methods, indicating a positive effect. Similarly, Shang Junjie and Zeng Jialing (2022) developed the educational game "Folding and Unfolding Blocks", finding that students' mathematical knowledge and psychological abilities significantly improved after three days of gameplay, especially for those with lower prior knowledge [10].

However, some studies (e.g., Charlier & Bieke 2013) have found that educational games negatively impacted learning, showing lower test scores in emergency knowledge compared to traditional methods. Additionally, research by Guttorm et al. (2009) found no significant difference in the learning outcomes between students using educational games and those using traditional methods, suggesting the impact of educational games remains inconclusive due to immature theories and limited research perspectives.

### **3 Research methods**

#### 3.1 Literature review

This method systematically collects, consolidates, and analyzes existing literature. Relevant Chinese literature was searched using keywords like "educational games", "teaching games", "digital game-based learning" and others. English literature was searched with terms like "educational games", "serious games", "digital games" and related terms like "learning performance", "learning achievement", "learning outcome".

#### 3.2 Quasi-experimental research

This method evaluates the impact of specific interventions on groups, though it has limitations in random assignment and control groups. It is used to assess the actual effects of educational games.

#### 3.3 Meta-analysis

Meta-analysis reprocesses multiple independent studies by standardizing results such as correlation coefficients, means, and standard deviations into effect sizes for comparison [4]. It reduces bias and ensures scientific objectivity [11].

### **4 Research results and conclusions**

#### 4.1 Research results

Overall impact: Educational games have a moderately positive effect on student learning outcomes, affirming their educational value [12].

Impact by knowledge type: Both theoretical and practical knowledge show moderate improvement through educational games [12].

Impact by learner group: Educational games positively impact all educational levels, especially in primary education [13].

Impact by subject: Effective in both humanities and sciences [13].

Story integration: Games with storylines have more positive effects.

Participation mode: Group participation is more effective than individual participation [4].

#### 4.2 Research conclusions

Through analysis, the study concludes that educational games have a moderate positive impact on learning outcomes compared to traditional methods. They create an enjoyable learning environment that boosts student motivation. They are especially effective in hands-on technical subjects by providing repeated practice. Group participation in games yields higher achievement, and games with storylines have a more positive effect. Educational games are effective in both humanities and sciences, enhancing learning outcomes across subjects.

## 5 Issues and challenges

With rapid technological development, educational games have gained attention as innovative teaching tools. However, current research faces several key challenges:

### (1) Lack of long-term studies

Current studies often lack long-term observation, which is necessary to confirm whether the improvements seen in the short term will be sustained and translate into lasting academic achievement.

### (2) Limitations in experimental design

Research designs often lack control groups, making it difficult to assess the true impact of educational games. Small sample sizes also raise concerns about the reliability and generalizability of the findings.

### (3) Balancing education and entertainment

Finding the right balance between educational content and entertainment is challenging. Too much emphasis on education can make the game dull, while too much focus on entertainment can reduce the educational value.

### (4) Disconnection from curriculum

Some educational games do not align well with academic standards, leading to a disconnect between the game's content and the curriculum, which can result in students learning incorrect or irrelevant information.

### (5) Inadequate evaluation methods

Current evaluations tend to focus on test scores, often neglecting other important learning outcomes such as problem-solving skills, critical thinking, collaboration, and the overall impact on students' motivation and interest in learning.

## 6 Recommendations and outlook

Given the current state and challenges of applying educational games in teaching, this study offers the following suggestions to support the sustainable development of educational games in educational practice:

### 6.1 The need for long-term research

Current studies mainly focus on short-term effects, lacking understanding of the long-term impacts of educational games. It's necessary to adopt a learning science perspective and conduct long-term studies to better understand the lasting effects of educational games on academic achievement. This can be achieved through longitudinal research, tracking students' engagement and learning processes over time. Additionally, incorporating theories from cognitive science, such as learning and cognitive development theories, can help reveal the long-term cognitive effects of educational games.

### 6.2 Improving experimental design

To address the limitations in current research, more rigorous methods and techniques are suggested:

#### (1) Introduce control groups

Including control groups that do not use educational games or use traditional methods will help accurately assess the impact of educational games on learning outcomes.

#### (2) Increase sample size

A larger sample size can reduce errors caused by individual differences and improve the reliability and generalizability of the results. Involving multiple schools, grades, and regions can further validate the effectiveness of educational games.

#### (3) Incorporate learning science methods

To better understand students' learning processes and psychological activities in educational games, methods from learning science, such as eye-tracking technology and brain imaging, can be used to gather more objective data.

### 6.3 Balancing education and entertainment

Learning science provides deep insights into the learning process and cognitive characteristics, guiding the design of educational games that balance education and entertainment. Strategies include:

(1) Incorporating learning theories

Integrate theories like constructivism and cognitive load theory to innovate game design, catering to different cognitive levels and stages.

(2) Diversified game experiences

Create varied game experiences for different age groups and educational backgrounds, offering both fun and knowledge.

(3) Gamification elements

Use rewards, tasks, and role-playing to boost engagement and focus on learning.

(4) VR and AR technologies

Utilize VR and AR to create immersive learning environments that enhance both entertainment and educational outcomes.

#### 6.4 Integrating educational games with curriculum

To ensure alignment with academic content, strategies include:

(1) Subject analysis

Match game content with curriculum, ensuring continuity and depth.

(2) Design optimization

Optimize design based on cognitive psychology to better facilitate knowledge transfer.

(3) Cross-disciplinary integration

Design games that integrate multiple subjects for comprehensive learning.

(4) Evaluation and feedback

Incorporate real-time feedback to adjust game content, ensuring alignment with academic goals.

#### 6.5 Comprehensive evaluation methods

To fully evaluate educational games, the following should be considered:

- Comprehensive evaluation: assess knowledge application, skill mastery, and problem-solving.
- Learning trajectory analysis: use data to track learning progress.
- Self and peer assessment: gather multidimensional feedback.
- Emotional and motivation surveys: measure emotional attitudes and motivation.
- Collaboration and critical thinking assessment: evaluate collaborative and critical thinking skills.

### **Conflicts of interest**

The author declares no conflicts of interest regarding the publication of this paper.

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