

The Effectiveness of Games for Educational Purposes: A Review of Recent Research

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This article reviews the literature that compares the instructional effectiveness of games to conventional classroom instruction. Studies dealing with empirical research rather than teachers' judgments are reviewed. Published reviews of research in English dating from 1963 to 1984 were examined and the literature was searched for studies from 1984 to 1991. Of the 67 studies considered over a period of 28 years, 38 show no difference between games and conventional instruction; 22 favor games; 5 favor games, but their controls are questionable; and 3 favor conventional instruction. Results for social sciences, math, language arts, logic, physics, biology, retention over time, and interest are examined. Math is the subject area with the greatest percentage of results favoring games, but only eight studies have adequate controls. Thirty-three out of 46 social science games/simulations show no difference between games/simulations and classroom instruction. The authors conclude that subject matter areas where very specific content can be targeted are more likely to show beneficial effects for gaming.

KEYWORDS: *educational; effectiveness; evaluation; instructional; games; review; simulations.*

Because many students enjoy playing games, it has often been asked whether this play aspect could be combined with instruction to enhance learning. This observation led educators to explore the feasibility of using a game format to supplement or replace the teaching of a variety of subjects. Educators discuss raising student interest with motivating approaches like games, but the educational efficacy of such approaches has not been well documented. This article reviews the literature on the effectiveness of games as a learning vehicle.

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Games are competitive interactions bound by rules to achieve specified goals that depend on skill and often involve chance and an imaginary setting (cf. Cruickshank & Telfer, 1980). Simulations model a process or mechanism relating input changes to outcomes in a simplified reality that may not have a definite end point. Simulation games are a subset of games (Reiser & Gerlach, 1977), and educational applications often depend on the learner reaching conclusions through exploration of input changes on outcomes. Highly motivating games have the characteristics of challenge, fantasy, and curiosity (Malone, 1981). In this review, we examine games and simulation games that have potential educational benefits. Most of the games are computerized, whereas most of the simulations are not.

Relatively few research studies of the educational effectiveness of games have been conducted (Butler, Markulis, & Strang, 1988; Jolicoeur & Berger, 1988). Much of the work on the evaluation of games has been anecdotal, descriptive, or judgmental. A trend of enthusiastic emphasis on direct applications of games to enhance learner interest overshadowed effectiveness research during the 1980s when creative game techniques were being evolved. The scanty research base during this period may be due in part to reduced support for research projects in which technology transitioned to the classroom and was evaluated (U.S. Congress, Office of Technology Assessment, 1988). Most recent evaluations of educational software have examined characteristics of the games rather than learning effects.

The Educational Products Information Exchange (EPIE) reviewed the use and effectiveness of gaming techniques in 170 commercially available, educational computer software programs (Dunne, 1984). Teachers trained to use an evaluation instrument rated each program on several variables. A program that involves the student in the instructional task was rated effective. Comparisons to conventional teaching methods were not considered. This type of evaluation of effectiveness is typical in the literature. In this article, we review studies in English that compare the effectiveness of games for instruction to conventional classroom methods.

We examined summaries of research on the effectiveness of games and simulation games in comparison to conventional teaching techniques published since 1966. The following seven reviews were published between 1966 and 1984:

1. In 1966, Cherryholmes reviewed six investigations of educational simulations in social sciences.
2. Over the course of 4 years, 10 research experiments were conducted using the Teams-Games-Tournament (TGT) instructional process on students in the 3rd to 12th grades (DeVries & Slavin, 1976). The TGT technique involved teams

of four to five students of heterogeneous ability levels playing games in a tournament and earning points for their teams. These studies measured the educational effectiveness of TGT in relation to traditional classroom instruction. Subject matter included math, social studies, and language arts.

3. In 1977, Pierfy reviewed 22 studies of simulation games and compared the simulations to conventional classroom activity. All of these studies involved social science topics, including economics, geography, history, and career planning.
4. Also in 1977, Reiser and Gerlach presented a review and critical analysis of research on simulation games in education. They report on some of the same studies as Pierfy (1977).
5. In 1981, Bredemeier and Greenblat reported on Pierfy's results and added other studies on the learning of cognitive as well as affective subject matter. Variables that may affect the outcome of studies on effectiveness of games are discussed. These include cognitive style, personality, academic ability, game ability, and administrative variables.
6. In 1982, Nawrocki and Winner reviewed the literature on the effectiveness of electronic game research, summarizing earlier reviews and reviewing some new articles (see also Nawrocki & Winner, 1983).
7. In 1984, Tolman and Allred reviewed four studies dealing with the effectiveness of instructional games as part of a larger review on computers in education. The subject matter of these studies was math in first through eighth grades.

Approach

The literature was searched for the past eight years using the data bases Psych. Lit., ERIC, and NTIS. The reviews listed above covered earlier periods. The searches yielded several hundred articles but those that did not use some empirical measure of educational effectiveness were eliminated.

This review includes the studies from the seven previous reviews and adds the individual research that has been completed since that time. Some earlier studies not considered in the reviews are also included. After presenting the findings from the research reviewed, we will discuss the many variables that need to be considered when drawing conclusions or making recommendations based on these findings.

Findings

This review is organized according to the subject matter of the studies: social sciences, math, language arts, physics, biology, and logic. The subject matter of studies has not previously been used in evaluating the effectiveness of games. We consider this a valuable area for investigation, due to the considerable differences in content and approach taken in these areas.

In addition to subject areas, retention over time and interest are considered. Business games are not included because they do not cover traditional academic subjects and because of the difficulty of specifying exactly what subject matter was taught, especially in management games. However, a review on business games from 1963 to 1983 (Wolfe, 1985) found results very similar to those presented here.

Social Sciences

In social sciences (usually called social studies below the college level), 46 studies ranging from third grade to undergraduates in college have been reported. Most studied simulation games. Some of the review articles overlapped in the studies covered, and care was taken not to count studies twice. The topics covered were history, geography, economics, educational psychology, politics, careers, and map reading. Included in this count are both the knowledge and intellectual skills categories used by Reiser and Gerlach (1977).

Thirty-three of the 46 studies showed no difference for simulation games over traditional instruction (Cohen & Bradley, 1978; Cherryholmes, 1966; DeVries & Slavin, 1976; Fraas, 1980; Klein & Freitag, 1991; Nawrocki & Winner, 1982; Pierfy, 1977; Raghavan & Katz, 1989; Reiser & Gerlach, 1977; Szafran & Mandolini, 1980). Ten studies favored games (Cherryholmes, 1966; DeVries & Slavin, 1976; Pierfy, 1977; Reiser & Gerlach, 1977), and three studies favored conventional methods (Pierfy, 1977). The review articles mentioned above cover more than one study.

Szafran and Mandolini (1980) showed no significant difference in student performance between using the simulation game, SIMSOC: A Simulated Society, and classroom instruction. College students were measured on an objective test and a concept recognition test. In another study (Cohen & Bradley, 1978), map reading skills of fifth- and sixth-grade students using simulation games did not show significant gains over classroom instruction. In a college economics course using simulation-gaming versus the lecture-discussion methods of instruction, neither method could be declared superior (Fraas, 1980). However, students without previous economic training achieved higher levels of postcourse economic knowledge and retention of that knowledge when assigned to simulation-games. Students with high precourse knowledge had better results with lecture-discussion. The game condition is a good introduction to the subject for more naive students. Supplementing an educational psychology lecture on information processing with either an instructional board game or a traditional worksheet produced no differences in performance on a constructed response posttest (Klein & Freitag, 1991).

However, students completing an assigned reading performed significantly better than those who did not. Also, the game group had higher scores on the motivation factors of attention, relevance, confidence, and satisfaction.

Using an intelligent tutoring system to simulate the economy of SMITH-TOWN, Raghavan and Katz (1989) found that students using the simulation achieved the same improvement in learning as did the students in a college introductory economics class, with a savings of 7 hours out of 12 hours for the simulation students. When the simulation was used as an adjunct to classroom learning, students using SMITHTOWN showed a sharper growth in the learning curve than the classroom-only group. A more detailed analysis of this work on the most efficient learning behaviors revealed that those involved in thinking and planning by way of hypothesis testing were more successful (Shute & Glaser, 1990).

Math

Computer games are reported to be very effective in improving mathematics achievements scores. Seven of eight studies on the use of computer math games found the games produced significant gains in math achievement for students in first grade through junior high school (Allen, Jackson, Ross, & White, 1978; DeVries & Slavin, 1976; Watkins, 1986; Weusi-Puryear, 1975). One study found traditional classroom instruction plus a drill and practice computer game for first-grade students were no more effective than traditional classroom instruction alone (Spivey, 1985). Three other studies also showed positive results for students using games, but can be questioned on a lack of control for time spent in learning math (Allen & Ross, 1975; Jolicoeur & Berger, 1988; Kraus, 1981).

Using an arcade game as a reinforcer for computer math drills improved the math achievement test scores of first graders over those who received an equivalent amount of conventional math instruction (Watkins, 1986). Games significantly improved learning in a computerized drill and practice math lesson for third to sixth graders over those who did not have the game opportunity, even though the game-playing students did fewer exercises (Weusi-Puryear, 1975).

The math game EQUATIONS has been shown to be effective for increasing math achievement. Four months of instruction using gaming resulted in an average increase in arithmetic reasoning of 1.3 years, seven months more than the average gain in the control class (Egerton, cited in Allen et al., 1978).

In four separate studies, the Team-Games-Tournament approach, which used the EQUATIONS game, was found to have a positive effect on achievement

in mathematics compared with traditional classroom methods (DeVries & Slavin, 1976). One of the studies found that the games-tournament component had a significant positive effect on math achievement whereas the team reward structure did not. The team component facilitated the group process.

Using computer games and tutorials to teach fractions as an addition to classroom instruction produced a significant gain in students' math achievement for fifth-grade students in eight schools. Overall, the tutorials were more effective than the games, but one of the two games used outperformed one of the two tutorials (Jolicoeur & Berger, 1988). Because the control group received less instruction than the "game" group, the effect may have been due to the extra instruction *per se*, rather than computer games or tutorials. The ability of junior high school students and their teachers to select ideas relevant to solving particular problems improved significantly through the use of instructional games (Allen & Ross, 1975); however, a nongame control group was not used. Kraus (1981) found that second-grade students using a computer math game with drill and practice on addition facts increased their math proficiency. In that study, the control group did not have additional classroom time on math, so again, extra time spent on math could account for the increase in math proficiency. Two recent studies were not included in the counts above. In one case, an order of presentation problem clouded the results (Bahr & Rieth, 1989). In the other case (Koran & McLaughlin, 1990), equivalent increases were found for game and drill conditions, but it was unclear if the drill condition could be considered to represent conventional instruction.

Language Arts

The language arts include reading, vocabulary, spelling, punctuation, syntax, and verbal analogies. Five out of six studies found positive results for games (DeVries & Slavin, 1976; Frederiksen et al., 1983). One study found no benefits for a gaming approach (Malouf, 1987). Two other studies with positive results for gaming can be questioned on the basis of lack of control for time spent in learning (Jolicoeur & Berger, 1988; Watson, 1988).

Four of the five studies showing positive effects for games over traditional instruction used the Teams-Games-Tournament (TGT) approach (DeVries & Slavin, 1976). TGT was also found to be superior to individualized instruction. Reading, vocabulary, spelling, punctuation, syntax skills, and verbal analogies were tested. Treatment specific test measures favored the TGT approach, whereas only some of the subtests of a standardized test proved significant. Further analysis found that the subtests of the standardized test that were not significant did not measure the specific tasks taught.

Frederiksen and his associates (1983) used a game-like training system to teach seven high school students who were poor readers. Components of a reading task were taught to build up automaticity in these subtasks. Trainees were able to reach levels of performance in the trained skills that equaled or exceeded those of high ability readers. The four students who finished the games increased their reading speed.

In a program designed to develop a vocabulary skill that involves matching negation prefixes to root words, learning disabled students in sixth through eighth grade produced equal gains in the task skill in game and nongame programs (Malouf, 1987).

Using a computer spelling game as an adjunct to regular classroom instruction for lower primary school children, Watson (1988) demonstrated an advantage of the game group over the control group who received computer practice on nonlanguage games. These results were obtained on a spelling test that closely reflected what was taught, but no difference was found between the groups on a standardized spelling test. By using the games, the experimental group spent more time on spelling than did the control group; therefore, the extra instruction could have produced the results.

Computer spelling games and tutorials produced a significant gain in the spelling achievement of fifth-grade students in eight schools. There were no differences between the performance of the game and tutorial groups (Jolicoeur & Berger, 1988). However, as there was no conventional classroom comparison group, the superiority of the software instruction cannot be claimed.

Physics

Using computer games to demonstrate Newtonian laws of force and motion, White (1984) showed a significant improvement in high school students' ability to solve dynamic physics problems over a control group that took the pretest and posttest only. Both groups had completed a physics course that covered the test topics. The game, which was played for one hour, allowed the students to make moves and to observe the consequences of their moves. This game was carefully designed to teach very specific topics and students were tested on the topics using paper-and-pencil tests.

Biology

High school biology students who were taught a portion of their instruction by simulation games had comparable achievement gains to those of the students taught by worksheets (Spraggins & Rowsey, 1986). The three

simulation games used in this study were able to teach factual information as well as did the worksheet activities. Each group received equal amounts of time on the assigned method.

Logic

Army personnel being trained in electronics diagnostic skills were given one hour of practice on the computer game, MASTERMIND, instead of extra practice on logic diagram reading (Kneer, Simutis, & Johnson, 1979). In the transfer task of reading logic diagrams, the performance scores of the game group did not differ significantly from those of a group given the extra practice, but the game group's accuracy scores were significantly poorer. The performance score was the proportion of total items for which the subject gave the correct answer; the accuracy score was the proportion of items attempted for which the subject gave the correct answer. These results give limited support for the use of games as an alternative to the usual training in reading logic diagrams, but the games were not shown to be superior to regular instruction.

Retention Over Time

Several of the studies measuring effectiveness of games included a delayed posttest to measure retention over time, ranging from 10 days to 8 weeks. Ten of the 14 studies measuring retention (Cherryholmes, 1966; Cohen & Bradley, 1978; Pierfy, 1977; Watson, 1988) reported significant results in favor of the simulation/games groups, whereas 4 found no difference in retention between the games group and the conventional group. Seven of the 10 studies that reported significant retention for the games group found no difference in learning between the groups at the immediate posttest.

Interest

In 12 of 14 studies (including studies in reviews), students reported more interest in simulation and game activities than in more conventional classroom activities (Cherryholmes, 1966; Cohen, 1969; Pierfy, 1977; Whitehill & McDonald, 1990). In a special summer program for junior high students who were either not interested in or not benefiting from traditional classroom approaches, 87% of the students said that the games used were more interesting than traditional teaching methods (Cohen, 1969). Eighty-seven percent of 94 Navy students studying basic electricity and electronics said they enjoyed using the computer to practice circuit problems, and 68% preferred

it to other methods (Whitehill & McDonald, 1990). Half of the 94 students used a game situation.

Summary of Findings

We summarize below the findings of the studies we have discussed.

1. We examined 68 studies directly or indirectly (in reviews conducted before 1984) on the difference between simulations/games and conventional instruction in student performance:

38 (56%) found no difference
 22 (32%) found differences favoring simulations/games
 5 (7%) favored simulations/games, but their controls were questionable
 3 (5%) found differences favoring conventional instruction

2. Seven out of eight studies involving math found that the use of games is superior to traditional classroom instruction for improving math achievement. The one study in physics was also favorable. Subject matter areas where very specific content can be targeted and objectives precisely defined are more likely to show beneficial effects for gaming. Games may also be effective in drill and practice situations with numerous highly related instances.
3. The greatest number of studies on simulation/gaming is in the area of social sciences. The majority of these studies (33 out of 46) showed no difference in student performance between games/simulations and conventional instruction.
4. Five out of six studies demonstrated that games can teach language arts effectively, particularly when specific objectives are targeted.
5. Social science simulations/games tend not to use a computer, while math, physics, and language arts games (except for the TGT approach) tend to use a computer.
6. Simulations/games show greater retention over time than conventional classroom instruction.
7. In 12 out of 14 studies, students reported more interest in simulation and game activities than in more conventional classroom instruction.

Discussion and Conclusions

This review covered a span of 28 years from 1963 (the earliest study considered by Pierfy, 1977) through 1991. That only 68 studies were reported in 28 years reflects a trend to use descriptive reports rather than empirical studies comparing games with classroom instruction.

Whether simulations/games should be used for educational purposes depends on subject matter. It is noteworthy that the TGT approach for games

was successful in four math studies but in only one out of three social science comparisons. For areas such as math, physics, and language arts, where the specific objectives can be stated, simulation/games can be used. This conclusion must be qualified because of the small number of research studies that have been conducted in these areas; that is, 11 studies for math, 1 for physics, and 8 for language arts. More studies are needed before the use of games could be strongly recommended. The results found for math and physics games should generalize to other technical areas.

In areas such as social sciences, whether games should be used or not is less certain. In this area, more than 72% of games/simulations were at least as good as conventional classroom instruction and 22% of the games were better. This finding is consistent with Van Sickle's (1986) report of a small effect size for social science simulations using meta-analysis procedures. Given the interest that games invoke and allowing for different learning styles or preferences, using simulations/games should be considered.

The positive results obtained for retention over time favors the use of simulation/games. Because games require the active participation of students, the material has a greater chance of being integrated into the cognitive structures of the individuals and thus being retained. Even some of the studies that show no gains at the posttest favor games/simulations at a delayed posttest. A possible reason for this could be the greater ability of the game participants to learn from the posttest and integrate what they learned into their existing cognitive structures.

That games/simulations are more interesting than traditional classroom instruction is both a basis for using them as well as a consistent finding. The greater interest in games holds true even when controls for initial novelty (Hawthorne effect) have been used. For classes that have motivation problems, it would be beneficial to introduce a gaming situation, because the increased opportunities for learning may vary with the content and game technique used. For subject areas in which only marginal learning effects have been found, instructional games could provide an alternative motivational technique to vary the presentation.

Several authors have identified variables that might affect the outcome of studies measuring the effectiveness of games. Bredemeier and Greenblatt (1981) present a thoughtful discussion of a number of important variables: personality, cognitive learning style, sex of the players, group variables, academic ability, game ability, and administrative variables. Researchers should be aware of these and other variables that we discuss in this article.

The measures used to demonstrate the effect of games should be given careful consideration. What a simulation is supposed to teach is often not specified, especially in the area of social sciences (Cherryholmes, 1966). In

these cases, if the test for effectiveness does not match what the game is teaching, negative results will occur. In some cases, treatment-specific tests revealed an effect of the treatment, whereas a more general standardized test did not. The reliability and validity of tests used to measure game effectiveness are often not reported. All but three of the studies reported by Pierfy (1977) employed investigator-constructed instruments. This may not invalidate a study, but it does raise questions regarding the results and can produce negative or insignificant findings if reliability is low. Although simulation games are often intended for a problem-solving approach to learning and should be tested appropriately, most game developers also expect a degree of knowledge acquisition that can be tested by a more objective test. Using both a multiple-choice test and a concept recognition test to examine the effect of the game SIMSOC, Szafran & Mandolini (1980) found that only the multiple-choice test produced a significant difference in favor of the game group. Using both a multiple-choice test (Iowa Test of Basic Skills, map skills) and a concept development test, Cohen and Bradley (1978) found no differences between the control and game group on either posttest, but they did find a significant difference favoring the game group on the delayed multiple-choice test. Using both measures yielded beneficial results.

A related issue is the use of the same instrument for the pretest and posttest, rather than a parallel form. If there is a short time period between the same tests, a practice effect could occur or the pretest could cue the student on what should be remembered from the game experience.

Sampling is another issue that should be considered in evaluating the effectiveness of games. Random sampling may not be used (as pointed out by Fraas, 1980), or whether it is used or not may not be specified (Shute & Glaser, 1990). Frequently, researchers are limited to using intact classrooms for comparisons, but these classes can be matched on the pretest and evaluated on other variables. Teacher bias toward a particular teaching method should also be considered, especially if, as occurred in some of the older studies (Pierfy, 1977), the game developer was conducting the study to evaluate his or her own game. If enough classrooms or students are available, the effects of different teachers can be examined experimentally.

Debriefing is a variable that may affect game outcome, but researchers do not agree on its effectiveness. Debriefing refers to the postgame discussions on the concepts learned, generalizations made, or applications of the game. Debriefing is more likely to occur in social science simulations. The educational effectiveness of a game with and without the debrief has not been systematically studied. If the teacher leading the discussion makes suggestions or the insights of a few are passed to the group members (Pierfy, 1977), can we attribute learning to the game itself or to the debriefing? Reiser and

Gerlach (1977) suggest that debriefing not be included as part of a game in research studies unless it is studied as the independent variable. Where debriefing has been used, research does not always show enhanced learning (Bredemeier & Greenblat, 1981; Szafran & Mandolini, 1980). There is a need for researchers to specify if debriefing is used and how it is carried out.

While most studies in this review did not examine an individual game over a long period of time or over many plays of the game, there are some exceptions. The game EQUATIONS has been evaluated extensively with attempts to manipulate aspects of the game to make it more successful. One successful version was a computer simulation of EQUATIONS in a solitaire version using experienced players for six 48-minute sessions over a 2-week period (Allen & Ross, 1975). In a scoring variation, EQUATIONS was successful in teaching math even when the players were not experienced with the game (Allen et al. 1978). The economics game SMITHTOWN has also been played for longer periods of time (up to five hours) and was introduced by a guide that explained the game plus an online demonstration of how the game was played (Shute & Glaser, 1990). This type of introduction to a game is not often mentioned in the studies reviewed. Evaluators should provide time for familiarization to study the true effect of the game when the game is complex. Less complex games may need little familiarization.

Features of games that make them successful should also be examined. Malone (1981) found that elementary school children prefer games with goals, computer scoring, audio effects, unpredictability, and where the speed of an answer counts. With recent technology, graphics could probably be added to this list (cf. Bobko, Bobko, & Davis, 1984). We need to know what features of games correlate with educational effectiveness. Preference tells us only which games people like to play, but not the extent to which they learn from these games.

No study has reported on the remedial use of games for those students who have not succeeded in traditional classroom instruction. However, the TGT studies found greater effects in mathematics achievement for low ability classes than for average ability classes (DeVries & Slavin, 1976). A fruitful area for further inquiry would be to investigate the usefulness of games for students with marginal skills or marginal motivation.

Some studies on gaming claim that games improve learning because practice with games in addition to the usual classroom instruction produced better test performance for the games group than the control group. If the control group gets either no equivalent classroom time on the same subject matter or equivalent time on a game in another subject, the gain shown by the games group may be due to either the extra instruction or the gaming element. Therefore, these types of studies do not provide good evidence that

games increase learning. The increase in learning could be due to the games or the extra time students spent on the subject matter. On the other hand, in a meta-analysis of research on computer-based instruction, Kulik and Kulik (1987) found that the time-on-task differences could not explain the positive results of evaluations of computer-based instruction. Studies that controlled for time-on-task produced nearly the same results as did studies without strict controls on instructional time.

Finally, the experimental design of research on games needs more attention. Appropriate experimental designs should reduce confounding from teacher bias, Hawthorne effect, test instruments, selection variables, and time difference for treatments. Remus (1981) presents a minimal checklist of confounding factors to be considered when using students as subjects. Research papers should include more details on the experimental design so that their results can be evaluated without question. There is also a need to report means and standard deviations for treatment groups so that the magnitude of the effect can be gauged and meta-analyses can be performed.

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