# MATHEMATICAL GAMES IN SECONDARY EDUCATION

by

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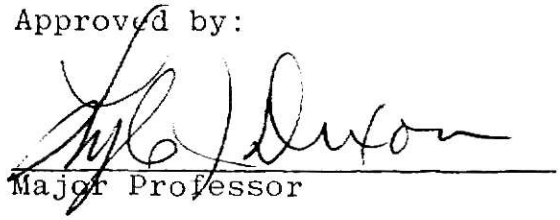

Major Professor

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# INTRODUCTION

For centuries, chess and war games have often been played to increase the strategical ability of its participants. Likewise, during the last several decades, business games have often been played to increase management abilities of its participants. So some types of educational games have been around for some time. But games have appeared in the secondary classroom scene only during recent times. The first games were introduced to the secondary classroom in the early 1960's along with other alternative and supplemental educational methods and instructional media like computer assisted instruction, teaching machines, and educational television. Most of these alternatives have now either died, are dying, or have been incorporated into the instructional process. This is not true of games however. Because games were not played in significant numbers in the secondary classroom, games and gaming are still in a relatively innovative period.[2] And one of the reasons "that gaming is not more popular is that there have been relatively few games available."[3] This is especially true in the field of mathematics. And like the number of games, there have been relatively few studies of the relative merits of the use of games to supple-

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[1]Robert C. Meier, William T. Newell, and Harold L. Pazer, Simulation in Business and Economics, (Englewood Cliffs, New Jersey: Prentice-Hall, Inc., 1969), pp. 179-182.

[2]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 166.

[3]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 75.

ment tradition methods of instruction. So the purpose of this paper is not only to discuss the playing of games, the designing of games, and illustrating a number of serious games and simulations in mathematics, but also to discuss the advantages and disadvantages of the use of educational games in the secondary classroom. And the reader should remember that, although this report is intended for mathematical education in secondary schools, much of this report is relevant to all games utilized from the elementary grades on up.

## WHY CONSIDER GAMES?

> The basis of formal education...has been the transmission of knowledge by the teacher to his pupils. This basis depends on the presupposition that the child is motivated to learn the content that it is felt essential for him to possess. . . Frequently these incentives [that are to motivate him like grades and diplomas] result in information being learned for a specific purpose such as an examination . . . then quickly forgotten. . . [It has been suggested] that our goals for education should be to help people to become enthusiastic, to assist them in learning how to learn, and to provide them with the resources and aids which are necessary to further their opportunities to learn.[1]

But not only does there appear to be a lack of proper motivation in the schools, there also appears, in contempory education, to be many serious gaps between what is being taught in the school systems and what is needed to be known for an effective life outside the school system. "This discrepancy between instructional practice and post school practicality is attested by the repeated worldly success of mediocre students and the quite modest worldly accomplishments of many outstanding students."[2] "To Coleman (Professor Social Relations at John Hopkins University) the American high school, established in a simpler time when only a small proportion of adolescents continued beyond grade school, has failed to come to grips with the tougher problems of the mid-20th century. He notes that today high schools are expected to prepare young people from all walks of life for a far more

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 20.

[2]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 15.

complex and impersonal society."[1]

So present methods fail to motivate students and are perceived as failing to prepare students for the real world. Because of these two reasons, schools appear to be ineffective.[2]

Thus, if present methods are indeed inadequate, then it becomes a necessity that other educational methods and media be examined as to their utility as alternatives and supplements to contemporary techniques in order to correct these problems. But regardless of the inadequacies of contemporary methods, it is always to the advantage to the conscientious instructor to examine supplemental or alternative educational methods. And serious games and simulations should be among those methods examined. For "simulations and classroom games could supply part of the answer to some of the problems that have been mentioned above."[3] It is for this primary reason that serious games and simulations will be further discussed and examined.

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[1]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 16.

[2]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), pp. 15-16.

[3]P. J. Tansey and Derik Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 72.

## DEFINITIONS

"Games", "Gaming", "Serious Games", "Simulations", and "Models", terms used in this report, often have different meanings to different individuals. Thus it becomes necessary that lucid definitions of these terms be given.

"Gaming" obviously means playing a game. But the word "game" has two commonly accepted definitions. The most common is that "a 'game' is a contest played according to rules and decided by skill, strength, or apparent luck."[1] The other is reduced to more specific terms. "A game is an 'activity' among two or more independent 'decision-makers' seeking to achieve their 'objective' in some 'limited context'."[2]

It is obvious that the difference between the terms "games" and "serious games" is the adjective serious. But serious is meant:

> in the sense that. . . [serious] games have an explicit and carefully thought-out educational purpose and are not intended to be played primarily for amusement. This does not mean that serious games are not, or should not be entertaining.[3]

So serious games differ functionally from the ordinary sense of games only in the intended educational goal in their design.

Simulations are also games having an explicit and carefully thought-out purpose. "Simulation is often described as a process

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[1]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 24.

[2]William A. Gamson, Simsoc (Simulated Society), (New York: The Free Press, 1972)(London: Collier-Macmillan Limited, 1972), p. 46.

[3]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 9.

involving the use of a 'model'."[1] And a 'model' is a representation--actual or theoretical--of the structure or dynamics of a thing or process. So a 'simulation' is an operating imitation of a real process.[2] Thus a simulation is a game which must have as its major component an abstraction of a real process, a model, upon which the game is based. However, not only should it be understood that simulations differ from serious games in the sense that simulations are based on models while serious games are not, but it should also be understood that, although a winner is usually identified in a serious game, there need not be a winner in a simulation. These differences will become increasingly clearer when the serious games listed in Appendix A are compared to the simulations in Appendix B.

Finally, it shall be assumed throughout this report that the work "game" refers to either "serious game" or "simulation" or both.

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 36.

[2]Idem, Learning Through Games: A New Approach in Education,

# GAME CRITIQUE

As in any teaching method or instructional media, there are advantages and disadvantages in using games in the classroom. It is the purpose of this section to briefly discuss those advantages and disadvantages. However, even though games have been around for ages, it must be remembered that the use of serious games and simulations in the classroom is relatively recent. Furthermore, few games have been developed and researched in secondary math education.[1] So many advantages and disadvantages have not had enough time to surface, and this fact should be kept in mind.

## Advantages of Using Games in the Classroom

A. Motivation. "What makes games effective, authorities agree, is their peculiar ability to motivate."[2] And "children who have become motivated in these subjects have their learning reinforced by participating."[3] "It (simulations) makes the (students) enthusiastic and gives them motivation. . . simulation is more enjoyable and more stimulating for high school and junior

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[1]G. I. Gibbs, Handbook of Games and Simulation Exercises, (Beverly Hills: Sage Publications, Inc., 1974), p. 53.

[2]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 10.

[3]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 52.

high school students than are other techniques that have been evaluated in comparison with it."[1] And motivation in any subject or topic is an advantage. A student who is motivated is more attentive in class and more prepared to learn the particular subject matter.[2] Games are thus particularly effective with mathematically apathetic students. So, in this manner, mathematical games

> help to develop a favorable attitude among learners towards symbol-manipulating activities, provide practice in abstract thinking, and teach something about mathematical logic. To this extent their value for those members of a group who do not like mathematics is obvious.[3]

B. Discipline and Control of the Classroom. Especially in junior high, discipline and control of the classroom must be present in order for effective learning to take place. Games are self-disciplining and provide control of the class. So the role of the teacher

> as judge or disciplinarian no longer exists when a simulation is in progress. There is no question of discipline problems. True, there is alot of movement and a high level of tal' on occasions, but there is no person who is constantly disrupting the class, for if he did this he would be interfering with his peers' enjoyment and they would not permit it.[4]

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 26.

[2]James Deese and Stewart H. Hulse, The Psychology of Learning, (New York: McGraw-Hill, Inc., 1967), pp. 211-212.

[3]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 28.

[4]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 27.

Thus it would seem that games provide control and that discipline improves when playing games, especially with games the students enjoy.

> Rarely do children in baseball or football games let the game fall apart because they cannot abide by the rules. Children do not want to play games they do not like, following someone else's rules, but they are generally happy to play, and often insist on playing, games they like by the rules of the game.[1]

C. Retention of Learned Material is Increased. "Involving the students in (a game). . . expands their knowledge greatly: they learn not only factual content but also the processes, relationships, and interactions involved."[2]

> One of the 'easiest' things about games is the incorporation of factual knowledge. The essential difference between this form of presentation and that of more traditional methods is that factual knowledge built into a game is needed immediately, and so is easily remembered, whereas the factual knowledge of a prescribed curriculum has to be stored against the 'possibility' of its being used some time in the future.[3]

Thus games not only motivate, but also reinforce learning, increasing retention of learned material.[4] Besides,

> if an activity having good educational results can offer, in addition, immediate emotional satisfaction to the participant, it is an ideal instructional method, motivating and rewarding learning as well as facilitating it.[5]

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 30.

[2]Ibid., p. 29.

[3]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 73.

[4]David A. Dushkin, Psychology Today: An Introduction, (DelMar, California: Communications/Research/Machine, Inc., 1970), pp. 106-107.

[5]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 13.

D. Simulations are Realistic Learning. Through simulations, students not only achieve educational objectives, but they also receive simulated experience in the real world. And instead of merely learning a simple fact or idea, a student relates that idea and fact to other ones in a game and, in turn, relates them to a wider framework.

> Games are effective teaching and training devices for students of all ages and in many situations because. . . They create dramatic representations of the real problem being studied. The players assume realistic roles, face problems, formulate strategies, make decisions, and get fast feedback on the consequences of their action. Also, with games one can evaluate the students' performances without risking the costs of having errors made in 'real-world' tryouts and without some of the distortion inherent in direct examination.[1]

"Moreover, games are self-teaching. The players learn from their own experience and that of other players within the game."[2] And so "games are useful because they force the students to live with the consequences of their decisions; this type of 'learning from experience' is very hard to get in the normal course."[3]

E. Games Promote Many Different Kinds of Learning. The learning that takes place in games "is 'whole-person' learning. That is, it functions integratively, combining the affective and behavioral domains with the cognitive domain always found in educational processes."[4] This concept is indeed advantageous,

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 13.

[2]Ibid., p. 67.

[3]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 49.

[4]J. Duane Hoover, "Experimental Learning: Conceptualization and Definition", The Proceedings of the First National ABSEL Conference, Oklahoma City, April 26-27, 1974, p. 31.

for learning does not take place through a few remote parts of our senses but through many.[1] It is, therefore, more efficient to appeal to many of our cognitive senses, behavioral senses, and affective senses at the same time. "Conscious learning realistically involves all the dimensions (mentioned above), at least to some extent."[2]

F. Games are Better than Traditional Methods. "Historically, however, retention of 'learned' material is less with the lecture method than with those methods by which students interact with others and actually use their newly developed skills in a realistic or real environment."[3] For instance, it appears that a game-centered lesson is more effective than a lecture-centered lesson in committing information to student memory.[4] Many instructors and school systems are having much success with the use of games and, in many situations, have found games superior in cognitive and affective results than the traditional methods especially in cases concerned with slow learners.[5] And many

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[1]David A. Dushkin, Psychology Today: An Introduction, (Del Mar, California: Communications/Research/Machines, Inc., 1970), pp. 76-77.

[2]J. Duane Hoover, "Experimental Learning: Conceptualization and Definition", The Proceedings of the First National ABSEL Conference, Oklahoma City, April 26-27, 1974, p. 32.

[3]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 123.

[4]David J. Fritzche, "The Lecture Versus the Game", The Proceedings of the First National ABSEL Conference, Oklahoma City, April 26-27, 1974, pp. 41-46.

[5]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 15.

authors, although not claiming that games work better than traditional methods, are writing that "they (simulations and serious games) work well in the junior schools as well as the senior schools."[1] For example, Nova High School (in Fort Lauderdale, Florida), one school in the country which not only incorporates the playing of games into their school but also sponsors a "Game Olympics" for the past several years, reports tremendous success with educational games. Funded by the Ford Foundation and the U. S. Office of Education, Nova High School has reported many successes in integrating academic games into the entire curriculum and in improvements in comprehension, recall, analysis, and synthesis of subject matter in students expecially among gifted and slow students.[2] Nova High School and a "growing number of schools are finding that various problem-solving games can be helpful in teaching everything from mathematics and business administration to international relations."[3] Hence, games must have worthwhile value in the learning process.

G. Compensation. Games also have the advantage of equalizing or compensating for differential student status or background and experience[4] so that each student is on the same

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 28.

[2]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, pp. 109-110.

[3]Ibid., p. 14.

[4]Ibid., p. 121.

level. Each has an equal chance.

In summary of their advantages, games thus seem to provide the student with motivation, the classroom with discipline, the student with experience and knowledge. And the games seem to work well in the classroom. In summary of those seven advantages, it should be apparent that

> there is no questions that games, when properly used, can have value. . . games can supplement other educational programs, making real and vivid material that often seems abstract in the textbook. If nothing else, they can convey to the player a feeling for the complexity and multiplicity of factors that must be considered in decision making. And conceivably they may increase the confidence of young people to deal with real world problems that seem possibly remote from their own lives.[1]

## Disadvantages of Using Games in the Classroom

Like any method, there are disadvantages. These disadvantages have resulted in the campaign of many critics against the use of games in the educational environment.

A. Game are not Better than the Traditional Ways. Many instructors argue that retention does not increase through the use of games over traditional teaching methods.[2] And, according to Cleo H. Cherryholmes, a political scientist at Michigan State University, "Students do not learn significantly more facts or principles by participating in a simulation than in a more con-

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[1]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 173.

[2]Ibid., p. 160.

ventional classroom activity."[1]

B. Faults Within the Game Design. Many of the disadvantages of games are discovered by critics to be within the design of games.

First, the motivation and competitive aspects of games have negative effects upon the participants. The motivation which most authorities agree that games provide may be a disadvantage and not an advantage. Motivation may encourage the aspect of competition too much, for it is believed by many that "competition is an aspect of our society which schools have emphasized too much in the past. Competition can often lead to disappointment and loss of dignity. . ."[2] Furthermore, competition may result in the fact that winning will become an end in itself and the education goal of the game will be bypassed. This may or may not encourage immoral or other unacceptable behavior on the part of the student.[3]

Other disadvantages can often be found within the design of "homemade" games. For instance, there may be a failure to involve all students actively in the games[4] or to provide ade-

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[1]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 171.

[2]P. J. Tansey and Derick Unwin, S mulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 91.

[3]Ibid., p. 169.

[4]Ibid., p. 74.

quate and accurate background information[1] or to be adaptable to different levels and difficulties of the students as well as the physical and temporal components of the classroom itself.[2] And because of their design and nature, games can be easily misused by the instructor. A game used improperly in the classroom becomes worthless as an instructional tool. That is, "the nature of games make them vulnerable to abuse, particularly in the hands of inexperienced or lazy teachers."[3]

C. The Cost-effectiveness of Games. But even when games are designed properly and used effectively, there remains a question as to their costs in terms of their effective results in the achievement of educational objectives.

"The costs of a serious simulation game are time, energy, and intellectual resources by the designer and the players."[4]

> Some useful criteria for evaluating both the costs and the effectiveness of games would be the active involvement and stimulation of all players; sufficient realism to convey the essential truths of the process being simulated; clarity of consequences and their causes in both the rules and the action; 'playability' in terms of the kinds of materials, space, and time required to achieve these results; and the repeatability and realiability of the entire process.[5]

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 57.

[2]Ibid., p. 75.

[3]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 173.

[4]Ibid., p. 111.

[5]Ibid., p. 112

In relation to answering questions about the cost-effectiveness of a game, we must ask ourselves,

> Did the game accomplish the purposes it was designed for? Did the players end the game with a heightened awareness of factors involved in the real situation that was simulated? Did learning take place more rapidly than with other methods? Did the players become aware of the simultaneous interaction of forces? Did they use and apply the information generated by the game? Was the learning material employed so as to increase retention over time? If the answer to these questions is 'yes', we still cannot necessarily conclude that the game in question is a more cost-effective instructional or teaching method than other alternatives.[1]

In conclusion, there have been a number of disadvantages mentioned. Whether or not these disadvantages are accurate and do indeed present inherent problems that should prevent the use of games cannot be determined at this time. This is partly due to the lack of large group testing and of large numbers of games to base the studies on. This is also due to the fact that the

> ability [a student receives from games] might be quite impractical to test because of the very long-term consequences involved. For example, even if a student playing an economics game does not memorize any terms of theories, or does not demonstrate any measurable change on conventional exams, perhaps ten years later he will make a much better economic decision.[2]

But maybe some of the problems with games could be avoided or don't actually occur. Perhaps the problems that do occur in the design of games can be avoided successfully. And it may actually be the case that games do teach facts and values, do

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 118.

[2]Ibid., p. 112

encourage children to think more critically, and do improve the decision-making ability of students better than other methods, for these are quite difficult questions to answer or to test.[1] And perhaps it should be remembered that

> it does not matter that the technique of simulation is measured against another method and found better or worse, for what teacher is there who has not felt, and felt often, the need for an alternative way of presenting information to a group of students who have failed to learn by other methods?[2]

Perhaps, in spite of the disadvantages, games ought to be considered as one of those methods.

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 75.

[2]Ibid., p. 7.

## PLAYING GAMES IN THE CLASSROOM

Games can be useful; for example, games can be used for research, planning, training, instruction, and, in the classroom, can be utilized in identifying specific types of nonverbal abilities.[1] But "the most obvious way to teach with games is to play them in the classroom."[2]

But merely playing games in a mathematics class will not insure that educational goals will be achieved. As discussed in the section entitled "Disadvantages of Using Games in the Classroom," a game that is improperly played in the classroom or improperly enveloped into the instructional curriculum of a lesson or educational objective loses its effectiveness upon the learning process. For example, playing a game without proper development of background information and prebriefing sessions before the game is played is like showing a film to a class without preamble.[3] The film then becomes only a source of entertainment, a break from the ordinary routine of the classroom, and not an effective instructional tool that could have been used to achieve some educational objective or goal.

> This, of course, raises the practical issues of topic selection, timing, logistic arrangements, casting, materials, special requirements imposed on teachers, and interactions with other curriculum material and activities.[4]

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 25.

[2]Ibid., p. 29.

[3]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 90.

[4]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 29.

With this in mind, the teacher should thus follow the outline given below if he is preparing to play any type of game in his classroom.

1. If possible, play the game through with other teachers or friends.

2. Become acquainted with the physical components of the game.

3. Thoroughly read the materials provided for the teacher's use.

4. Modify the game, if necessary, to meet particular needs of the class.

5. Decide the basis on which roles will be assigned. Try to include bright and slow students on the same teams.

6. Distribute copies of the rules, and profiles and sceneries where they are used, to each student the day before play.

7. Arrange the components of the game in the classroom.

8. Brief students on:
   a. the purpose of the game
   b. the roles of individuals or teams, and objectives
   c. the physical layout of the room
   d. the first move.

This phase should not exceed fifteen minutes.

9. During play circulate maong groups or individuals and offer suggestions where desirable, answer questions when necessary. Try to involve the student in answering his own questions and arriving at solutions.[1]

By following the outline above, the instructor will more effectively incorporate the game into his lesson plans and overall educational objectives while at the same time will maintain student enjoyment of the game.

But it is not enough for the teacher to be prepared before the game. He must be mentally prepared during the game as well

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[1]Alice Kaplan Gordon, Games for Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), p. 114.

as after the game has been played. During the game, he must be mentally aware of his role as a teacher. Traditionally, the role of the teacher is instructor, judge, and disciplinarian. During the game, this role changes. He becomes "an arbitrator, an explainer, coach, and conceivably a player."[1] So the teacher must be mentally prepared to accept this new role as a sideline participant or bystander and to abandon the traditional role of the central figure. Finally, after the game has been played, he must remember that a simulation game cannot and does not constitute a total educational program but is part of a larger process.[2] So the teacher must be prepared to follow through with planned activities related to the game after it has been played.

Even though it is not known whether or not serious games and simulations can be substituted for the traditional (or other) teaching methods, the teacher should always assume that games, by themselves, will never totally satisfy goals within an educational program. So, like films presented in class, games serve only to supplement other teaching methods in the instructional process. So as a supplement, a game is useful only when presented and incorporated correctly "within" the instructional program.

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 67.

[2]Elliott Carlson, Learning Through Games: A New Approach in Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 49.

## GAME DESIGN

No mathematics teacher should be satisfied with merely incorporating serious games and simulations into his educational curriculum, for there are so few games available for so many topics. So he must be prepared to create, to design, his games. For by designing his games, a teacher not only can design games for any educational objective he establishes, but he can also custom-tailor the game as he desires to meet either the specific criteria of that objective or the specific needs of the particular class in which the game is to be played. It is useful, therefore, that a guide, a cookbook recipe for designing games, is available to the instructor. Several such guides have been suggested.[1] So it becomes the purpose of this section to provide the instructor with such a guide. But before this is done, it must be noted that, although the steps for designing games can be spelled out and illustrated, it takes creativity and ingenuity on the part of the instructor to put the ingredients together in such a manner as to design a purposeful and successful game.

Step 1. Select Topic. First, the instructor selects a topic that he wants to teach.

> Most topics are suitable for educational gaming, some more than others; topics that involve multiple forces or actors in some form of mutual competition with uncertain outcomes are the most gameable. . . . On the other hand, some topics which may not seem actually suited to being gamed may be so remote from the students' interests that some form of

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[1]Elliott Carlson, the Foreign Policy Association's outline, Learning Through Games, (Washington, D. C.: Public Affairs Press, 1969), p. 136 and Alice Kaplan Gordan's outline, Games For Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), pp. 125-129.

> classroom activity is required to stimulate interest, in which case, games are a useful motivating technique.[1]

In mathematics, particularly, there are many, many topics that can be gamed.

Step 2. Determine educational objective. If a game is to be useful in relationship to the chosen topic, it must have specific educational objective(s) in mind. "When an educational game is being devised, the [next] step is to ascertain the educational objectives of the game."[2] For example, one educational objective might be that students will be able to solve word and non-word type mathematical problems involving the loaning and borrowing or money, involving the computation of simple interest. (See Appendix B for the Game "Survival".)

Step 3. Select mode or model of game. After an educational objective has been selected, it becomes easy to decide what mode of presentation or which model would best achieve the desired educational objective. For example, if the educational objective is for the student to add signed numbers together, the mode of presentation might be a card game, i.e., a serious game, as illustrated in Appendix A or the model might be based on the stock marker, a simulation game, which requires the computation of new values of stock as the stock indications go up (addition of positive values) or down (addition of negative

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press Incorporated, 1970), p. 29.

[2]Alice Kaplan Gordan, Games For Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), p. 125.

values). So at this point, it becomes a matter of deciding between a serious game or a simulation. Having now selected a mode of presentation or model, it becomes easier later

> "to decide on such items as the factual material that has to be including [in the game],. . . , the duration of each game, the number of players, and the constructs that will be placed on the playing of the game."[1]

Step 4. Identify key actors. Identify key actors in the process, whether it be individuals, groups, organizations, or institutions.[2] In a serious game, the only roles that may be required are the two-or-more decision makers. But there are often many roles to be defined in a simulation. For example, in a simulation based on borrowing and investing money in banks involving the computation of simple interest, a few of the key actors would be a Savings Bank and a Lending Bank with their respective bankers to manage them.

Step 5. Define roles for each participant. It is important that each participant have a specific understanding of his activity in the game. His responsibilities and objectives should be clearly spelled out. Remembering that a game should have the "ability to instruct",[3] the instructor should place participants in such a position so that they can receive the most benefit from the game. This step is very crucial, for

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 54.

[2]Alice Kaplan Gordan, Games For Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), p. 129

[3]Idem, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 90.

the most important single part of a game is

> "involvement" in a role. [It alone is enough to motivate the student and create within him enthusiasm about the subject matter.] In simulations, this can be achieved by introducing an element of realism [a "good" model], it is true. It can also be achieved by making the participant commit himself to a role.[1]

Step 6. Determine resources. Determine the resources that the participants will need. This may be "play-money", board tokens, dice, stock certificates, word problems, or even scratch paper, which are to be used during the game, or it may be background information that needs to be presented before the game.

Step 7. Determine the rules of the game. Determine the decision rules or criteria, and player instructions by which each participant must abide in playing the game. "No serious game can be successful if the players do not understand its rules, their objectives in the game, the consequences of their actions, and the reasons for these consequences."[2] Furthermore, if a spirit of competition between players, between groups of players, or even inside the player himself is designed in the rules, then a game will often be played with more enthusiasm and hence increase the effectiveness of the game. Almost always, instructors will install in the rules an element of chance. The element of chance, if used in the proper porportion, always adds spice to the game. It allows a "losing" player to gain

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 46.

[2]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 115.

and can also stall a winning player. However, many instructors allow the element of chance to play too big a role in their games (refer back to disadvantages of using games in the classroom, p.13). Serious games and simulations are games to instruct, and thus must allow the skill of the participant to decide whether or not he is successful.[1]

> In this sense serious gamed [and simulations] 'should' differ from more conventional games. They should respond more to the conscious decisions of the players than to an outside element of chance. . . . Thus, "Monopoly" is not an ideal instructional game, because winning depends more on the rolls of the dice than on the decisions made.[2]

Step 8. Check playability of a game. A game is often not successful because of inherent inadequacies in one or more of the steps above. The usual problem in design lies within step 7. For instance, too many games fail because the rules are too long or unclear. So the

> best indicator here [of the playability of the game] is in the rules and player instructions. If these are too lengthy or are unclear, they are reflecting uncertainty and lack of clarity in the game design itself.[3]

The rules and player instructions should also create a game that is challenging, but neither too difficult or complex nor too easy.

> A puzzle is no fun if one knows the answer or if it is impossible to solve. The games should stress the students' own discovery of heuristics, computational techniques, and

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[1]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Education Ltd., 1969), p. 57.

[2]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 115.

[3]Ibid., p. 116.

> scientific facts as instrumental to his objectives in a contest with nature or with other students.[1]

Furthermore, a game is playable only if a "player . . . (is) able to determine the relative effectiveness of his playing, who won or lost . . ."[2] or whether he did well or poorly. So some form of scoring system should be designed within the game. A scoring system is not only good for the students but also for the teacher who utilizes the game in the classroom, for scoring also provides what psychologists call 'closure' to the activity, completing it in a psychologically satisfactory way."[3]

So in testing the playability of a game the instructor should check that the rules are clear, the game is challenging but not too complex or easy, and that some form of scoring system has been designed within the game.

Step. 9. Test-play the game. "Finally, the game is shaped by repeated trial and error."[4] Many fallacies in the design of the game become apparent only when played repeatedly by the instructor. For example,

> if the game requires too many players to interact, acquire information, and make decisions which, in turn, affect the interactions and decisions of other players, then the game has not been adequately test-played.[5]

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 38.

[2]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 33.

[3]Ibid.

[4]P. J. Tansey and Derick Unwin, Simulation and Gaming in Education, (London: Methuer Educational Ltd., 1969), p. 81.

[5]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 116.

With each repeated testing, the designed game will become more effective in achieving its intended purpose.

Step 10. Adapt the game. The designed game should now be custom-designed for the specific class in which it will be used. A successful game is adaptable.[1] It allows for varying levels of difficulty and complexity of the student. It should also allow for time and physical space changes if possible.

Step 11. Inspect the design of the game. Finally, the instructor should recheck the previous ten steps against his game design remembering always that "games can be interesting without being solemn, interesting without being hilarious, earnest and purposeful without being humorless, and difficult without being frustrating."[2] Stanley C. Vance of the University of Oregon gives the following advice for the instructor inspecting his game design:

> 1. Keep your game understandable and simple in structure; the fancier and particularly the mathematically exotic games tend to be one-shot ventures.
>
> 2. Make it realistic. The game should be a learning experience. Since life and reality are synonymous, the closer you get to reality the longer life expectancy you give your game.
>
> 3. Give it flexibility. Adapt or perish is just as pertinent to decision simulation as it is to the preservation of living species.
>
> 4. Be sure it is purposeful. While classroom stimulation and having fun can and should be integral to game-playing, it must have pedagogical and, hopefully, research value.

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[1]Alice Kaplan Gordan, Games For Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), pp. 147-148.

[2]Clark C. Abt, Serious Crimes, (New York: The Viking Press, Inc., 1970), p. 10.

> 5. Live your game. Even a near-dead game will be resuscitated by academic mouth-to-mouth first aid. Many an excellent game has been prematurely consigned to the mortuary because of lackadaisical instructors.[1]

In summary, an instructor who decides to incorporate games into his lesson plans, needs to also know how to design them. A guideline was given for instructors to follow in designing their own games. The outline was as follows:

1. Select topic
2. Determine educational objective
3. Select mode or model of game
4. Identify key actors
5. Define roles for each participant
6. Determine resources
7. Determine rules of the game
8. Check playability of the game
9. Test-play the game
10. Adapt the game
11. Inspect the design of the game

Following this outline carefully, the instructor is guaranteed to have designed a successful and useful game.

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[1]Stanley C. Vance,"Long Live Your Business Game", Association for Business Simulations and Experimental Learning, The Proceedings of the First National ABSEL Conference, Oklahoma City, April 26-27, 1974, pp. 31-35.

# CONCLUSION

When schools fail to motivate students or when they are perceived not to relate to the real world, then it becomes necessary to examine other teaching alternatives. Games are one such alternative. Games can be used successfully in achieving educational objectives as a supplement to other teaching methods when properly played in the classroom and designed correctly.

We conclude this report with words from Clark C. Abt.

> In education, there are no substitutes for highly motivated and creative teachers, relevant and exciting school texts, imaginative and well-planned curricula providing individualized instruction, and effective and well-designed school facilities and plants. But the day has not yet arrived in which all these ideals florish in all school systems, and until that day does arrive, games will play an important role in educational life. Games are not a panacea for all the ills of the educational system today, but they do provide fast and effective relief for some of these ills. The challenges posed by educators by the problems involved in planning games force them to deal with new problems and to see old problems from larger or different perspectives. Thus games serve a creative as well as an analytic function in educational planning and programming.[1]

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 27.

# APPENDIX A: SERIOUS GAMES

In this section, the rules to a number of serious games of mathematical nature can be found. A discussion of a serious mathematical game as well as the titles of a number of mathematical games are also included.

## Card Games

> The deck of cards used in one set of math games we have devised is especially constructed to allow for the greatest freedom in making moves, to have enough cards of a given number value to make problems generated at random solvable, to allow for rapid play, and to introduce enough elements of chance to be interesting and competitive. There are sixteen cards for each number value from 0 to 9, and eight 'wild cards' which can represent any number from 0 to 9.[1]

A. On the Button.

> Two or three players each start with two cards. The rest of the deck remains face down. The object of the game is to hit the target number 20 exactly, or 'on the button'. Each player in turn discards a card, and adds it aloud to the total already played. A new card from the deck is then drawn. The player who reaches the target of 20 exactly wins the cards for that round. When the entire deck is used up, the player with the most cards wins the game.
>
> If players fail to meet the target 'on the button', cards that were played remain on the table and are taken by the player who meets the target in the next round.
>
> If a player makes a mistake in the game, and is correctly challenged by another player, the challenger wins all the cards on the table at that point. If the challenge is incorrect, the challenged player wins the cards.
>
> Variations in the game include starting with the number 20 and using subtraction, aiming for the target number

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 41.

of zero. More complicated versions of the game involve the use of addition, subtraction, multiplication, and division in one play.[1]

B. Equation Match.

> Each player is dealt, face down, a specific number of cards depending on the number of players. . . , and three cards are turned face up on the board. The dealer makes the first move, the dealership rotating in successive rounds. The players, in turn, combine any two or more cards on the board through addition, subtraction, multiplication, or division, or any combination thereof, to reach a number which matches one of the cards in his hand. The player then captures all those cards. If a player cannot take any cards, he must place a card from his hand on the board.[2]

C. Equation Rummy.

> The game operates in much the same way as 'Equation Match' except that each player is required to use a specified number of cards from the board in each match; two or three, depending upon the players' level of skill. Each player is also required to reach as match totals all the numbers from 0 to 9. After the match is taken by a player, he places the match face up in front of him with the card on top so that he knows what number matches he must still get to win the game. The first person who makes all the matches from 0 to 9 wins the game. Players receive two points for each match in the 0 to 9 series. In the event that no player is able to make the complete run from 0 to 9 before the deck runs out, the winner is the person with the highest total.[3]

D. Equals.

> The object. . . is for each player to make an equation from the cards he holds in his hand. The game is played equally well with two to four players [and is easily adaptable to team playing]. At the beginning of the game, at least four cards are dealt to each player. Each player looks at his cards and applies whatever arithmetic processes his teacher allows so

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[1]Alice Kaplan Gordon, Games for Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), pp. 80-81.

[2]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 137.

[3]Ibid., p. 135.

that two cards combined, or three cards combined equal a fourth card.

When a player can make an equation in his turn, he places the cards on the board and recites his equation. If he is correct, he keeps the cards as a 'book' and draws four more cards. If he is incorrect, another player may challenge him and win the book. If the player is incorrectly challenged, the challenger must give his opponent one of his books. If a player cannot make an equation on his turn, he discards one card and draws a new card. If he can make an equation using his new card, he must wait until his next turn to do so. The winner of the game is the player who has the greatest number of books when the deck has been used completely.[1]

E. Multiplication. Division.

Both games may be played by two to four players. To start either game, players draw cards randomly from the deck to set up a multiplication or division problem. On its simplest level the multiplication game employs a one-card multiplicand and a one-card multiplier. On its most complex level, the game employs a three-card multiplicand and a two- or three-card multiplier. The long-division game, on its simplest level, has only one card in the divisor and three cards in the dividend. On its most complex level, two cards are used in the divisor and five cards in the dividend.

After a problem has been set up, such as 32·7 or 563÷7, players are dealt a fixed number of cards. . . Each player in turn attempts to place one card anywhere it belongs in the solution to the problem. After he has done so, he places a marker on the card to identify it as his, and he draws a new card. If a player cannot place any of his cards in the problem, he places one of his cards face up in front of him saying, 'This number does not appear anywhere in the problem,' and draws a new card. If he has a number that has already been played in the problem, he places his card beneath the played card but does not put a marker on it; he then draws a new card.

If a student makes a mistake in placement, an opponent on his turn may challenge the placement by turning the card over and putting the original marker button beneath it; the challenger then puts his own marker

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[1]Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 138.

button on top of the card to indicate that he has identified an error. If the challenger has the correct card, he makes a move of his own.

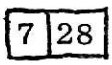
When the problem is solved, players count up their scores, counting one point for each marker button on a correct card and subtracting one point for each marker under an incorrect card. They then check the cards they have said do not appear anywhere in the problem. They score one point for each card they were correct in saying could not be played; they subtract one point for each card that could have been played.[1]

## Domino Games

A. Factor Stacks.

Two to six players each receive an equal share of the dominoes. The object of the game is to win stacks, or sets of dominoes. The player with the highest number of dominoes at the end of the game is the winner.

A stack represents a series of problems and solutions. In building the stack, each player puts down a domino containing a numeral that supplies a missing factor in the domino above. This move not only provides his solution, but sets a problem for the next player.

Example:
Player 1 puts down 

.

Player 2 puts down 

and says, '7 times 4 equals 28.'

The next player must use a domino with a 2 on it to continue play ($2 \cdot 2 = 4$). Each player states his solution aloud. The last player to move on any stack wins all the dominoes in that stack. Since a player can see all the other players' dominoes, he can develop a strategy to shut out his rivals and take the stack for himself.[2]

B. Quotient Rummy. Common Factor Chain. Multorfactor.

These are all games based on a variation of "Stacks".

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[1] Clark C. Abt, Serious Games, (New York: The Viking Press, Inc., 1970), p. 142.

[2] Alice Kaplan Gordon, Games for Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), p. 82.

## Spinner Games

The spinner games provide practice in operations with fractions. Materials consist of cards, with double spinners and printed numerals, game boards, and colored markers. The pointers on the spinners are used to indicate the fractions. The game boards have two uses. On one side is a 'fraction wheel' on which the games can be played; it can also be used as an aid by students calculating fractions. Colored pegs are included for use in some games.[1]

A. Sum It.

Two or three players each spin six fractions on the spinner, and place a marker on the fraction wheel. For example, if a player spins a 3 and a 2, he places a marker on 2/3 on the fraction wheel. Each player then sums the fractions he has spun and moves the markers to the appropriate result. Thus, if a player adds $\frac{1}{2}$ and $\frac{1}{2}$, he moves one marker to 1 and one marker to 0. The player with the highest sum wins.[2]

B. Bumper. Tic-Tac Fraction.

These are both games based on variations of "Sum It".

"Cards", "Dominoes", "Spinners" are games manufactured by: Abt Associates for : D. C. Heath and Co., 125 Spring St., Lexington, Mass. 02173.[3]

Other suggested games are "Wff'n Proof", "Real Numbers", and "On Sets".

## A Geometry Game

Students play the game in teams of two. They stand at the chalkboard in front of the classroom; separating them is any kind of partition or barrier that prevents

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[1]Alice Kaplan Gordon, Games for Growth: Educational Games in the Classroom, (Chicago: Science Research Associates, Inc., 1972), p. 85.

[2]Ibid., pp. 85-86.

[3]Ibid., p. 198.

each of them from seeing the other's portion of the board while permitting the rest of the students to see what both of them are doing. . .

After the students are at the board, the teacher draws a figure from a typical geometry text on the board on one side of the partition only. With a member of the class acting as time keeper, the team is directed to begin. The student who sees the figure must describe it to his partner so that he can draw a satisfactory replica. When the team decides that it has finished, the timekeeper announces how much time it took to duplicate the drawing. If the figure is not judged to be similar enough to the original, the team is disqualified from the competition. If several teams produce acceptable replicas, the shortest time wins.

. . . In order to play the game well, it is necessary for the students to know the proper descriptive terminology (such as chord, tangent, secant, external point) and to have an appreciation for precision of expression. When the players do not communicate properly, the class can see a necessity for precise language and, it is hoped, can enjoy the confusion of the players.[1]

## A Structure for Unstructured Lectures

In considering what type of game should be used, the author immediately eliminated all previous 'well-structured' mathematical games. It was his opinion that the game should possess an element of chance, while yet being intellectually stimulating. The game should be flexible enough to allow the most simple problems along with the 'almost' impossible. The game items should be related to the material under discussion, and should have a self-contained review that would eliminate the long boring conventional pre-test review sessions.

Rules for Contest:

1. Each team will be determined at random by selecting slips from an envelop.
2. The quiz items will consist of algebra problems. Some problems will be taken from the text, some problems will be taken from other algebra books,

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[1]James B. Caballero, "A Geometry Game", The Mathematics Teacher, February, 1974, pp. 284-285.

others will be constructed by the teacher.

3. The captains of the teams will rotate, so that each player will at one time serve as captain.
4. There will be two envelopes. One envelope will contain the regular quiz items; worth 1 point, 2 points, 3 points, lose your turn, lose 1 point, 1 point free or take another turn. The other envelope will contain the bonus items. The bonus questions will be considerably more difficult than the others. Each bonus item is worth 5 points.
5. Teams will alternate in selecting items from the envelope of their choice. The point value of each question and the amount of time are allotted on each slip.
6. If the team that selects the question cannot answer in the allotted time, then the other team may respond, provided the question is not of true-false or multiple choice nature.
7. A winner is determined each day. During the following class meeting new teams may be formed.

The game served three major functions: (1) It retained the interest of students for long periods. (2) It helped to imprint the basic facts in the students' minds. (3) It provided an avenue for stimulating discussions on mathematical topics.[1]

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[1]D. Ferguson, "A Structure for Unstructured Lectures", The American Mathematical Monthly, 81, (May 1974), pp. 513-514.

# APPENDIX B: SIMULATIONS

In this section, three simulations are presented. One is presented and then analyzed and discussed, and the other two are presented as games which were designed by the author. Other simulations will be listed.

## Consumer

> In Consumer, which calls for 8 to 16 players, participants play the roles of consumers, credit and loan managers, and salesmen. The game's objective is to teach adolescents about the economics and problems of installment buying. This is done by placing the students in a 'simulated environment' in which situations arise not unlike those in real life. Thus, players must weigh the added cost of financing a purchase against the additional value to them of having the item now. They must also compare the interest rates charged by different financial institutions, such as banks and personal loan companies.
>
> In the game, students learn that it's often a wise strategy to defer immediate comsumption pleasures in order to improve their credit rating or put their economic affairs on a sound basis. During the game, consumers receive a monthly income with which they may buy certain products. They receive satisfaction or utility points for each item purchased. But the exercise is structured in such a way that the desired item for purchase may be at its greatest value precisely when the consumer is short on cash.
>
> The consumer is also plagued by random events, such as accidents or unemployment. Thus, players are often faced with the need to borrow, to buy a product or pay some emergency bill. The winning player is he who maximizes his utility points while at the same time minimizing credit or interest charges for which he is penalized.[1]

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[1]Elliott Carlson, Learning Through Games: A New Approach to Problem Solving, (Washington, D. C.: Public Affairs Press, 1969), p. 115.

Survival: The Mathematical Money Game
of Saving and Borrowing with Simple Interest
(designed by David E. Ewing)

1. Topic: Money problems dealing with simple interest.
2. Objective: The student should be able to work word problems and non-word problems concerned with the saving and borrowing of money involving the computation of the simple interest formula $A_t=P+PRT$, where $A_t$ is the total amount of money after time t measured in years, P is principle, R is the rate of interest, and T is time measured in years.
3. Model of Game: The model upon which this simulation is based is the need to make money by earning it or borrowing it or saving it in order to pay bills and make payments on a house.
4. Key Actors: There is "Factory A" from which participants can buy for $1 word problems concerned with simple interest that are worth $10 or $30 when completed successfully by the participant. Likewise, "Factory B" has problems worth $20 and $40. Each factory has a manager who earns $40 in cash and $30 in savings in the bank of his choice each round that he is manager. And, if determined by the teacher, each factory has an assistant manager who earns $35 in cash and $20 in savings in the bank of his choice. It is the duties of the manager and assistant manager to sell word problems to the participants, check completed problems and award money as appropriate, and to make housing payments, bill payments, and saving and borrowing transactions as other participants.

There is "Bank A" which can loan money at 8% simple interest plus $5 cash each round and save money at the simple interest rate of 5%. "Bank B" can loan money at 9% simple interest and can save money at a simple interest rate of 7% provided the money is deposited for two rounds or longer. Each bank has a president whose housing payments and bills are automatically paid each round he is president and who receives a $50 savings account at the start of the game. It is the duty of the bank president to handle all money transactions in his bank, keeping a careful record each round, and computes during each round the current values of savings and loans made during the previous round.

There is "Bill Collection Agency C" which accepts and records the house payments each round. It also presents a "fate bill", discussed below, chosen by chance to each participant and accepts money from or pays money to the participant as his "fate bill" dictates. The agency is managed by two co-managers whose salaries are the same as those of the assistant factory managers'. The co-managers also must make housing payments and other transactions like the other participants.

"Fate Bills" are a deck of 60 cards, 40 of which direct the payment of bills with payments ranging from $5 to $100 and 20 of which reward money with amounts varying from $5 to $100. Each participant receives a "fate bill" chosen by chance from the "Bill Collection Agency C" each round.

"Change of Role" is a deck of 25 cards, eight of which contain the names of "key actors" in the game and the rest of

which have the name "worker". Towards the end of a round, a participant may try to change his role in the game by drawing from the "change of role" deck which is in the possession of the teacher. The card he draws will dictate the position he plays during the next round. Each participant may only draw once each round and must fulfill the position indicated on the card. He vacates his former position and replaces, if the card indicated a key actor, the participant who formerly occupied that position. A participant that has been replaced can either draw a "change of role" card or become a worker. A vacated position will be filled at random by the teacher before the next round starts.

All other participants in the game are classified as "workers".

5. Participant Role: Each worker, factory managers and their assistants, and the bill agency's co-managers must pay housing payments and "fate bills" each round. And they may make saving and borrowing transactions with the banks as they determine. Whereas the key actors have fixed salaries, workers must earn their money in the factories by buying problems from the managers and receiving money for problems successfully completed. The objective of each participant is to accumulate as much wealth as possible.
6. Resources: A sufficient amount of "play" money must be provided to the factories, banks, and the bill collection agency. Each participant should receive his designated salary with workers receiving $20 in cash and a $10 savings account in the bank of his choice.

The "change of role" cards and the "fate bills" should be prepared and furnished.

Sheets of paper should be furnished to key actors so that accurate records may be kept.

Simple interest problems should be prepared with the easiest ones being placed in the $10 and the most difficult in the $40 category and should be given to the appropriate factories. The teacher should provide an answer sheet to the factory managers so that they can check the accuracy of completed problems.

7. Rules: At the beginning of the game, key actors are selected. After the materials for the game have been distributed, each player indicates his choice of bank to the appropriate banker for his initial savings account. (A player can save or borrow money from any bank and does not have to transact with the same bank throughout the game.)

Each round consists of a 13-minute work day and a 7-minute transaction period. Except for the co-managers of the bill collection agency, each participant performs the work assigned to his position in the game during the 13-minute work day. During the transaction period, a housing payment of $50, and a "fate bill" are paid, and saving and borrowing transactions take place as the participant decides. The co-managers make their transactions during the work day and work during the transaction period. At the end of the round, the participant may, if he wishes, approach the

teacher for a "change of role" card.

Stock Market: A Mathematical Game
that Works with Percentages
(designed by David E. Ewing)

1. Topic: Percentage.
2. Objective: The student should be able to work money problems that involve computations with percentages.
3. Model: The simulation is based on a model of the stock market where the values of stock may increase or decrease unexpectedly.
4. Key Actors: In each group of about six students, one person is chosen by the members of the group to be the group's Stock Manager. The Stock Manager sells or buys stock from the other members of the group, keeps a careful record of the transactions that occur, keeps a record of the current price of stock for that group, and awards money.

   Another person is also selected in the same manner and becomes the Group Arbitrator. The Group Arbitrator rolls the die for the group and arbitrates the correct answer on the current value of the stocks.
5. Participant Roles: Each participant who is not a Stock Manager is concerned with the buying and selling of stock. At the end of the game, he sells all of his stock. His objective is to accumulate that largest amount of wealth that he can.

6. Resources: Each Stock Manager must be furnished with stock certificates, "play" money, stock record sheets, and a die. Play money should also include small change.

7. Rules: At the beginning of the game, each participant who is not a Stock Manager is furnished with five shares of stock worth $10 per share and $15 cash.

Each round consists of rolling the die, determining the new price of stock, and buying or selling stock to the Stock Manager.

The die, having been rolled, indicates the change in the value of the stock from the preceding round of the group and possibly awards cash dividends by the number showing on the top face of the die.

1 - reduction of 25% in value

2 - reduction of 10% in value

3 - no change

4 - increase in 10% in value

5 - increase in 20% in value & $10 dividend per player

6 - increase in 30% in value & $25 dividend per player

Now the group determines the new value in the stock. Each member figures the new value of the stock. Then the group consults together to determine which answer is correct. The Arbitrator has deciding vote on all disputes. A correct answer yields $5 cash reward to each player of the group who has it.

Then stocks may be bought or sold from the Stock Manager.

Three minutes are allowed for the roll of the die and the determination of the new value of the stock. And four minutes are allowed for stock transactions.

Recommended simulations that are produced commercially and that can be utilized in some secondary mathematics classes are:

(1) "Easy Money" and "Jet World: Trade and Travel Game" produced by Milton Bradley.

(2) "Stock Market Game" produced by Whitman at the Western Publishing Company, Inc.

Samples of resources for the "Stock Market" game are illustrated on the next three pages.

**THIS BOOK CONTAINS NUMEROUS PAGES WITH DIAGRAMS THAT ARE CROOKED COMPARED TO THE REST OF THE INFORMATION ON THE PAGE.**

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$1 $1

U. S. REAL PLAY MONEY ***

$1 NON-LEGAL TENDER $1

$5 $5

U. S. REAL PLAY MONEY ***

$5 NON-LEGAL TENDER $5

$10 $10

U. S. REAL PLAY MONEY ***

$10 NON-LEGAL TENDER $10

$20 $20

U. S. REAL PLAY MONEY ***

$20 NON-LEGAL TENDER $20

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# MATHEMATICAL GAMES IN SECONDARY EDUCATION

by

DAVID EUGENE EWING

B. S., Kansas State University, 1974

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AN ABSTRACT OF A MASTER'S REPORT

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MASTER OF SCIENCE

Department of Mathematics

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# MATHEMATICAL GAMES IN SECONDARY EDUCATION

## ABSTRACT

When educational processes fail to motivate the student to want to learn or when the teachings of the schools appear to have little connection with the real world, then it becomes necessary to examine and study other educational methods and instructional media as to their effectiveness in accomplishing educational objectives when used either as alternatives for or supplements to contemporary methods and media.

Serious games and simulations are two such methods. Serious games are defined to be those games having an explicit and carefully thought-out educational purpose while simulations are serious games based on a model, an imitation of a real process.

But, like other instructional methods in secondary education in mathematics, these have both advantages and disadvantages that must be discussed. The advantages in serious games and simulations are that they motivate and control students, aid the students in the retention of educational material and achievement of educational objectives, and simulate real-world experiences for the

student in the classroom without the real-world consequences for mistakes; the disadvantages are that games are not more effective than contemporary methods, have components in their design which produce undesirable traits in students, may not be cost-effective, and, as yet, are untried, untested, and unproven methods.

But, regardless of the advantages and disadvantages, many instructors of mathematics have felt the need to try new and different approaches to achieving their educational objectives. So many learn not only how to properly play, in the classroom, mathematically serious games and simulations but also how to correctly design them.

Now it is neither concluded nor suggested that games be used all the time to teach all things. But they could be effective in altering attitudes and achieving objectives when utilized in conjunction with other educational media.

This conclusion having been stated, examples of both serious games and simulations in secondary mathematics are given.