Sierra Nevada College

APPLICATIONS OF GAME THEORY IN EDUCATION

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Arts in Teaching

by

Chad Benson Hutchings

Dr. Maria Meyerson/Thesis Advisor

April 2012
We recommend that the thesis by Chad Benson Hutchings prepared under our supervision be accepted in partial fulfillment of the requirements for the degree of

MASTER of ARTS in TEACHING

____________________________________________________
Maria Meyerson, Ph.D., Thesis Chair

____________________________________________________
Christopher Rawlins, M.A.T., Committee Member

____________________________________________________
Trudi Abell, M.Ed., Committee Member

April 2012
# TABLE OF CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>List of Tables</td>
<td>iv</td>
</tr>
<tr>
<td>Abstract</td>
<td>v</td>
</tr>
<tr>
<td>CHAPTER I</td>
<td></td>
</tr>
<tr>
<td>Introduction</td>
<td>1</td>
</tr>
<tr>
<td>Purpose of the Study</td>
<td>2</td>
</tr>
<tr>
<td>Research Questions</td>
<td>3</td>
</tr>
<tr>
<td>Significance of the Study</td>
<td>3</td>
</tr>
<tr>
<td>CHAPTER II</td>
<td></td>
</tr>
<tr>
<td>Research Methodology</td>
<td>4</td>
</tr>
<tr>
<td>Limitations</td>
<td>5</td>
</tr>
<tr>
<td>Definitions of Key Terms</td>
<td>5</td>
</tr>
<tr>
<td>CHAPTER III</td>
<td></td>
</tr>
<tr>
<td>Review of the Literature</td>
<td>6</td>
</tr>
<tr>
<td>Elementary School Settings</td>
<td>6</td>
</tr>
<tr>
<td>Secondary School Settings</td>
<td>11</td>
</tr>
<tr>
<td>Adult Education Settings</td>
<td>20</td>
</tr>
<tr>
<td>CHAPTER IV</td>
<td></td>
</tr>
<tr>
<td>Critical Analysis of the Literature</td>
<td>28</td>
</tr>
<tr>
<td>Development of Educational Materials and Planning</td>
<td>28</td>
</tr>
<tr>
<td>Learning Assessment</td>
<td>30</td>
</tr>
<tr>
<td>Classroom Activity</td>
<td>31</td>
</tr>
<tr>
<td>CHAPTER V</td>
<td></td>
</tr>
<tr>
<td>Conclusion</td>
<td>40</td>
</tr>
<tr>
<td>Closing Thoughts</td>
<td>42</td>
</tr>
</tbody>
</table>
References ..........................................................................................................................44
## LIST OF TABLES

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 1</td>
<td>Game Theory in the Development of Materials and Planning</td>
<td>31</td>
</tr>
<tr>
<td>Table 2</td>
<td>Game Theory in Learning Assessment</td>
<td>36</td>
</tr>
<tr>
<td>Table 3</td>
<td>Game Theory in Classroom Activity</td>
<td>36</td>
</tr>
</tbody>
</table>
ABSTRACT

A critical analysis of 30 studies that either analyzed the applications of game theory in education or used game theoretical thinking to analyze educational dynamics was conducted to establish knowledge of game theory at three levels of education. A strong application of game theory in the fields of educational planning was observed alongside untapped potential for game theory in the field of assessment. While referenced studies found that there are ample risks in applying game theory to educational dynamics, this review concluded that game theory has strong current and potential applications across the spectrum of education and at all educational levels. The strongest applications appears in secondary education. Further research in direct applications of game theory in educational assessment was suggested to refine exploration into that particular field.
CHAPTER I
INTRODUCTION TO THE STUDY

Game theory is a widely researched subject in education, ranging from its application as a learning resource to usefulness as an assessment tool. For more than 40 years, researchers have questioned the applications of traditional game theory (Martin, 1978) as well as the more modern variants such as the active use of mnemonic and multi-learning style games to achieve a variety of learning goals (Skiba, 2008; Shultz, Colby & Colby, 2008). The question of game theory’s practicality and usefulness to education, however, still remains.

This critical analysis of the literature will examine the specific applications of game theory across all levels of instructor-led education. This goal is important because, while game theoretical thinking is passively used in many walks of educational life, active use of the concepts of game theory may extend and refine the utilization into a clearer, more stratified method of assessment of classroom tools for the betterment of all educational practice. In short, game theory can provide the educator with a system to test the system.
Osborne (2004) defined game theory as “a bag of analytical tools designed to help us understand the phenomena that we observe when decision-makers interact” (p. 1). The decision makers or “players” are actors whose cooperative and competitive interaction can be assessed and predicted. Situations where the cooperation or competitive elements between the players are recorded and quantified are called “games.” Tools are game theoretical concepts that can be used to describe the actions and interactions of the actors. For example, one popular tool to describe important interactions is Nash Equilibrium, (Martin, 1978). Nash Equilibrium is defined as a game where each player’s decision to act is based on awareness of the best and likely decisions of other players.

What is the place of game theory in the classroom? An adversarial relationship is a possibility in many aspects of educational practice, as is the case in any situation where multiple parties can contribute to the outcome of a situation. Game theory is designed to observe those relationships and condense them to each party’s wants and needs. Game theory is also designed to gauge the outcomes of these situations based on the cooperation or competition between parties.

**Purpose of Study**

This critical analysis of the literature studied game theory in traditional K-12 education as well as adult education in both technical and nontechnical environments. Specifically, the purpose of this study was to examine game theory within elementary, secondary, college, and vocational settings. This analysis will help educators understand the intrinsic motivational benefits of modern game theory against the extrinsic motivations of grading and/or monetary remuneration.
Research Questions

This critical analysis of literature was guided by these research questions:

1. What are the applications of game theory in the development of educational materials and planning?
2. What are the applications of game theory in learning assessment?
3. What are the applications of game theory in classroom activity?

Significance of the Study

The benefit of this analysis can be found in the application of game theory to education. An improvement in education for the K-12 and adult learners is an ideal consequence of an awareness of the current applications of game theory, the potential for the expansion of those applications, and the establishment of new ones. Furthermore, the refinement of the application of game theory to the training of a directed, non-contextual task, as is found specifically in vocational and adult training, will have an overall positive effect on task-oriented education.
CHAPTER II

METHODOLOGY

The sources for this work were searched primarily within EBSCOhost and ERIC. The primary term used was *game theory* with search results filtered by their application to task-oriented education rather than to applications of game theory in other fields, such as economics or employment attrition. A secondary term, *education*, was used as a refining term to focus on corporate training and task-oriented vocational training. A mix of action research, critical analyses of literature, and formal game theoretical analyses were reviewed for this study.

Additional resources were found through a search of textbooks on the educational applications of game theory. Textbooks provided sources on a wide range of studies but also the works that were found within prominence of the already established and publicized applications. Textbooks were readily searched through *Amazon* but were not to be used as primary sources. Textbooks as sources were primarily used for the purpose of definition of terms.
Limitations

Because of the limited nature of the material that is to be found on the subject, most of the studies included in this analysis will be published between the year of 1978 and 2011, with a high concentration in the decade from 2000 to 2010. Excluding studies and works cited for the purpose of definition rather than exploration, only peer-reviewed sources that use appropriate methodology and provide clarity of purpose and result will be included.

Definition of Key Terms

Several key terms are used as necessary throughout this work to provide a basic understanding of game theory as it applies to educational practices.

Game Theory The use of situational models to analyze interactions between two or more rational players of a game based on motivations, risks, benefits, and results of cooperation and competition (Osborne, 2008, p. 1).

Game A situation that can be summarized and analyzed based on previously noted game theoretical elements (Osborne, 2008, p. 1).

Prisoner’s Dilemma A game where the primary motivation of the players is to not cooperate, despite the fact that the biggest reward to be gained is from cooperating (Osborne, 2008, p. 12).

Nash Equilibrium A game situation wherein each player knows the chosen strategy of the other players and is not motivated to change his or her strategy, and all players are therefore in strategic equilibrium (Osborne, 2008, p. 11).
CHAPTER III
REVIEW OF THE LITERATURE

The body of literature covering applications of game theory is organized into three categories for the purpose of this study. The first category consists of studies that assess dimensions, techniques, and usefulness of game theory in elementary settings. The second category of utilized evidence includes similar factors, but focusing on secondary settings. The third and final category includes studies that assess the same elements of game theory but applied to adult and postsecondary education and training.

Elementary School Settings

De Fraja, Oliveira, and Zanchi (2008) examined the possibilities and useful elements of Nash Equilibrium, a particular element of game theory, through a statistical analysis of involved effort structures for students, teachers, and the parents. The researchers addressed the lack of information on multilateral efforts in the classroom as well as a lack of useful definitions of “effort”. The authors defined “effort” as a measure of attitude via a meta-analysis of previous literature. Through that definition, they reassessed the metrics of several previous game theoretical studies based on that redefinition. Once this was established, the authors concentrated on several mathematical
proofs, assessing the effort of student, school, and parent as either complementing factors towards an ever-increasing output or factors that contribute in varying measures towards a static goal.

In the final phase of this study, the authors applied those proofs to reality, assessing the National Child Development Study, an assessment of participant motivation and effort, done on a cohort approximately 12,000 British participants from their births in 1958 until the age of 42. The proposed statistical models were tested via the British National Child Development Study. They provided the researchers with ample information to judge effort, as well as the efficacy of their proposed models of effort input vs. educational success. The particular questionnaires of the National Child Development Study were taken when the participants were age 7, 11, and 16. Some information regarding the measured efforts had to be inputted based on predictive models, leaving the possibility for a moderate margin of error within the study. The study provided several interesting conclusions. First, the efforts put out by a school had a sometimes negative effect on participants, but a net neutral or positive effect on parents, whereas effort by parent or child seemed to cause the other to reciprocate with his or her own effort.

Ferguson (1971) provided a warning about the uses of game theory in an educational environment in a game theoretical analysis, bolstered by outcomes that differed from that analysis. According to the author, game theory concerns itself with “means and not ends” (p. 1) and fails to consider the cases when the player in a given game is not rational or party to the motivations that game theorists may ascribe to them.
The author acknowledged that game theoretical studies are useful in specific situations and under certain circumstances, using a case study of game theoretical teachings of a social science class as an example and more specifically focusing on games such as the prisoner’s dilemma. Ferguson noted, however, that game theory’s limitations of a two-person interaction and often zero-sum situations, when one party’s success is always countered by the other party’s failure, cause it to be improperly used beyond those interactions. Furthermore, game theoretical studies do not account for the irrational player, and children are often irrational. This is not a cause for the dispensing of game theoretical analysis from educational fields, but instead for a tempering of its use, as to avoid overconfidence and improper uses of game theory.

How do educators know if a more literal game that also works in the realm of game theory, is going to be effective in the classroom? How do educators know that game is going to be effective? Through an analysis of the literature, Wilson, et al. (2009) examined how the traits of games and the outcomes they will produce within the classroom can be organized to allow educators to easily select the best game for each classroom purpose. These researchers provided a framework that analyzed 12 specific traits of learning games and their exact relation to learning outcomes by the skills acquired. For example, the authors took the skill of “compilation,” provided several subskills and traits that made up the skill as a whole, such as “have ability to generalize and discriminate information,” and “substages: guided response mechanism, complex overt response” as well as requisite learning outcomes and their traits, and, finally, provided the methods for evaluating the acquisition of those traits and skills, such as
“targeted behavioral skills” (p. 225). This study provided a baseline for future studies of
game theory in education, allowing for a stratification of both terminology and
methodology of assessment.

Sanford and Madill (2007) provided a game theoretical analysis of the advantages
and pitfalls present in using games in literacy education. The authors specifically noted
the expansion of the definitions of literacy and how game education fit within that
expansive definition. To provide a basis for their study, Sanford and Madill chose to
work with subjects at a 9-week long summer camp and their instructors acting as camp
counselors. The instructors were between the age of 11 and 16 years old and the students
were primary school age. This provided a somewhat different set of motivations for both
parties. Instead of monetary and future professional motivations, the educators were
possessed of social and more immediate motivations, such as positive reinforcement by
camp administration, whereas the students were motivated by social reinforcement via
the educators as well as the less stressful grading environment of enrichment-based
summer school education. The authors hypothesized that there would be increases in
literacy and motivations of the instructors, who were also the designers of the educational
games that were used.

The authors observed the lessons and held focus group sessions with the students
and instructors to assess the levels of motivation achieved by the lesson structure and
classroom environment. Outcomes of the learning were also assessed to confirm an
increase in both traditional literacy as well as more modern, expansive literacy for the
students. The authors specifically challenged the notion that games are simply a vehicle
for violence that is used to indoctrinate youth and put forth the notion that they are instead, like literature, an emerging form of art that can be put to a variety of uses.

Slater (2004) applied game theoretical rules dynamic of caring within the classroom. In addition to using game theoretical rules in the analysis, Slater also used the philosophies of Lao Tzu and specifically focused on elements of Nash Equilibrium. The study focused on the motivations to care, and not care, within the classroom for student and teacher. While observing the motivations within the philosophies of Lao Tzu and Nash, the author then expanded the scope of the analysis, noting the risks of caring. As a critical analysis, the study provided the groundwork for use of conceptual game theory as an analytical tool of classroom practices.

When applied to the “digital native” generation, what is the significance of game theory and game based learning in the classroom? Divjac and Tomic (2011) researched the sudden rise in the popularity of games in education as well as the study of game theory in education. The authors aimed to define the impacts of mathematical games on learning, on motivation, and on the realization of educational goals. To achieve those aims, they conducted a critical analysis of available literature on the subject, providing a multinational cross-section of studies of gaming in education and the answers provided to each of the study’s essential questions. The authors concluded that gaming education has a positive effect on the realization of educational goals, motivation, and educational outcome. The authors provided a qualification to this conclusion, however, and noted that the games must be pedagogically designed.
Secondary School Settings

How does game theory help in overall lesson design and the selection of high school classroom material? Shelton and Scoresby (2011) provided a possible answer to this question. The researchers asked three essential questions in their study: (a) How can games be implemented in a successful goal-aligned classroom, (b) Why and how are games a good way to align goals and promote achievement in the classroom, and (c) What specific types of game and game tasks can be used with these goals? The authors answered these questions through a series of case studies.

The subjects of the study were seven instructional designers who volunteered to assess each game. The authors also did a more cursory study in the application of each game within the classroom. Participants’ understanding of the subject matter covered in each game was assessed with multiple-choice tests. The authors concluded that the games excited the passion of the teachers in the creation of the gaming lessons and the involved challenge, but that the usefulness of the gaming lessons within the classroom could not yet be predicted.

Kebritchi (2010) also conducted a case study but focused on the risks of game theoretical elements from the teacher’s perspective. The author identified the factors controlling whether teachers adopt a theoretical game by allowing three experienced math teachers who were also experienced with computing to give an in-depth assessment of a single, popular learning game and its advantages and risks. The author provided two measures of successful adoption of a learning game to assess its risks and possible rewards: adoption factors and integration barriers. Adoption factors were defined as traits
correlated with making the adoption of the game within the classroom easier. Integration barriers were defined as factors that could prevent the successful adoption of the game within the classroom. Kebritchi noted that the adoption factors of a targeted learning game do not correlate with that game’s successful learning utility but instead with the adoption factors as they pertained to teachers, whether or not those factors coincided with learning ability. Further study was recommended to assess learning through games as well as adoption issues related to school administration.

The study of game theory has greatly expanded to overcome previous limitations of communication in recent years thanks to the Internet. Huang, Huang and Tschopp (2010) analyzed the relationship between motivation and outcome of a single, online-based learning game. The study was conducted with 264 participants whose progress and motivation were gauged with an Instructional Materials Motivational Survey (IMMS) based on the 2010 Adult Reading Components Study (ARCS) System. The authors found conclusively that, in online-based game models used for education, motivation has a direct correlation with improved outcomes.

The applications of game theory in the classroom are not only in curriculum. Game theory can also be used to analyze the dynamics of participant behavior in the classroom. Elstad (2002) studied Norwegian participants and asked three questions: (a) Why do students who are uninterested in materials still learn?, (b) Why do students cease to behave well after achievement exams and before the National Matriculation exams?, and (c) Why does student behavior suddenly dissolve into raucous behavior when a substitute is in control of the classroom, even for normally very well behaved students?
Elstad analyzed these dynamics each as a game theoretical construct, comparing the motivations for cooperation and competition for each situation for both the student and the teacher as actors in a game. Elstad invoked the presence of transactions between the students and teacher (or substitute) in each of the situations. A transaction, as defined by Barth (1981), is an exchange between parties in a game that can either facilitate or hinder motivation for cooperation. The transactions in these situations happened both between individual students and the teachers, and the whole class of students and the substitute teachers. Each player follows its own set of rules. Elstad described all three situations as a “Prisoner’s Dilemma” (Axelrod, 1984).

In a Prisoner’s Dilemma, each of two players has one of two options. They can take the positive strategy that results in reward for them and penalty for the other player, or they can take the negative strategy that results in a greater reward for them and penalty for the other player, but will decrease the likelihood of the other player using the negative strategy in further rounds of the game. Thus, the most positive situation in a game of Prisoner’s Dilemma is one where the consequences of the negative action are made plain. Elstad also performed a case study of a prestigious school in Oslo, Norway and analysis of two game situations that directly affect students within that classroom. The first is between the teacher and the standardized system framework that dictates the success or failure of the students by national standards. The second pertains specifically to a situation where the teacher is only in a classroom to teach and prepare for a situation where marks of success or failure are given to the students, rather than also providing those marks. Elstad performed an extended analysis of the applications of game theory in
assessing each situation and then proceeded to analyze each situation via those same
game theoretical terms. The conclusion offered by Elstad for this study was not only that
game theory has a logical and potentially very useful place in pedagogical theory, but
also that a strategy of open cooperation, per those game theoretical results, is the key to
classroom control.

Stull (2004) broadened the study of educational game theory even further,
applying it to the integrations of vocational and academic curriculum within high school
classrooms to create a stronger unified field. To supplement the analysis, Stull provided a
simplified definition of Curriculum Integration (CI) to specifically refer to cases where
vocational material is integrated into academic curriculum on the teacher level. From the
analysis of the dynamics present in CI, Stull provided three implications. First and most
importantly, CI is not always the best decision for a school and must be applied only in
cases where it is merited. Second, CI is most effective when the decisions are made on
the teacher level, rather than the administrative level. This can be done in a democratic
fashion by teachers, but if the teachers make the wrong decision (choosing CI when the
opposite is appropriate or vice-versa) then redirection by administration may be
necessary. The larger the population of the students involved in the curriculum, stated
Stull, the more closely watched the results will have to be. The reason for this statement
was due to presumed more dire negative implications of the wrong decision in larger
populations. No recommendations for further study were provided.

Elstad (2006) also used a rather extreme example of a “Laissez Faire classroom”
to analyze the usefulness of game theoretical elements in planning the actions of a teacher
in controlling classroom behavior. Through a case study, Elstad analyzed extreme teacher dis-involvement. The teacher gave students simple, basic directives as to what topic they were to study and then gave the students complete control over the lessons and teaching the subjects to one other. Without teacher involvement, the students became disaffected and often talked with each other about non-learning topics.

Using a theoretical game with the teacher and students as opposing parties for whom cooperation yielded moderate benefits for both, Elstad performed a case study of a single classroom that practiced a “Laissez Faire” structure and a curriculum based in Information and Communication Technology (ICT), allowing students to learn at their own pace and self-police in their learning practices. In game theory terms, this situation is called a “Prisoner’s Dilemma.” The author concluded that this game did not provide ample motivation for the participant to perform and that the solution to this particular issue was to have the teacher be much more involved and in a directorial role within the classroom, rather than taking the role of the advisor.

How does the use of the theoretical game in the classroom translate to quality assessment and learning so that average students can prepare to enter a professional workforce? Cotton, Ahmadi, and Esselborn (1997) explored this question in great detail. Using the summary of educational goals provided by the Secretary’s Commission on Achieving Necessary Skills (SCANS) in 2000, the authors attempted to match the use and results of game theoretical lesson planning to the goals of a workforce-preparation geared educational system. The hypothesis held by the authors was that learning games would give participants a stronger foundation to the necessary knowledge and skills by
providing consistent abstraction and usage of the concepts necessary to master each lesson. The authors studied a range of games individually, playing them with a moderator present and assessing each game based on the utilization of three knowledge/skill elements: basic, thinking, and personal. The authors concluded that educational games have much potential to be useful, but should be judged carefully on their utilization, potential for skill-building, and application to the subject at hand.

How can the application of game theory help the student to contextualize lesson information? Abrams (2009) studied the applications of a gaming environment to contextualize classroom information in a case study of three struggling adolescent male students. Information for the first case study was gathered from four hours of classroom observation and ninety minutes of one-on-one interview. The second and third case studies were much more intensive, including 74 hours of in-classroom observation, five follow-up interviews, and a literacy survey before and after the implementation of the contextual game-based learning, learning activities that center around choices by the student to cooperate or compete in real-world situations. The findings of the study were that the presence of game theoretical concepts, especially those conforming to the more modern standards of game theory that involved games in the sense of play, provided context and visualization for the students. For the struggling student, contextual basis was found to be the difference between a complete lack of interest in the subject, and a strong interest and drive to complete and learn from the activity.

Game theory is now also being applied to very complex concepts, such as computer programming Wang and Chen (2010) conducted a specific study of the use of
gaming models to educate and motivate students. The difficulty in the advanced tasks, according to the authors is the highly abstract nature of advanced programming. This is a field that emphasizes specific application of a lexicon to a wide range of activities rather than situational processing for a limited number of tasks. To effectively describe and assess the usefulness of game design, this analysis adopts a cyclic model of learning, going from active experimentation, to concrete experience, to reflective observation, to abstract conceptualization and then back to experimentation. The tools of assessment for the study were two games: (a) a “matching-challenging” game that provided embedded concepts and allowed the students to match actions to those concepts, and (b) a “challenging game” that provided students with a target endpoint but no prompting concept, and limited time to achieve an answer. The experience of the student for participants was judged through a Likert-scale game preference questionnaire and a standard grading rubric. The challenging game increased learner absorption in the game, however, the matching game increased learner achievement and scoring. The results of this study suggest that an increase in participant motivation and involvement in the educational task did not necessarily correlate with an increase in performance.

The use of game theory to create a competitive classroom environment may have a very positive effect on student motivation. Burguillo (2010) conducted a study via survey to gauge student motivation and satisfaction when approached with ten competitive learning games designed to create an environment of friendly competition within the classroom. The subjects of the study were the students of five courses that implemented competition-based game learning over ten years. Competition-based game
learning, learning where students are placed into groups and placed in a competitive setting with a defined and clearly communicated educational goal that provides extrinsic rewards, be they grade points or other rewards with the potential to motivate students. Student interest and motivation was gauged with a survey taken at the end of each course.

Burguillo also provided a guide for the implementation of those games as well as feedback on each, acting as a basis and how-to guide for the implementation of game theory activities as well as a prediction of their outcome. The study concluded that competition-based game learning can be used to great effect in almost any learning style. Furthermore, it was found that in the competition-based learning environment, learning can be further focused by having a “tournament” of sorts at the end of the course, focusing student goals on the long term “win” as well as the short term.

Can the use of competition in the game theoretical classroom go too far? Dubey (2010) explored this question in detail in a study that explored the use of three different scoring elements to score student motivation: curved grading, grouped grading by score, and percentage scoring. Dubey approached the questions from a standpoint of game-theoretical mathematical proof with three conclusions: First, broad grading methods, grouped by grade rather than displayed as individual scores, provide students with extra motivation to elevate their performance and be in a higher group than they already are. Second, grading on a curve hinders student motivation and creates too much competition, resulting in the punishment of students who are performing at high levels if there are more students at those levels than the curve allows. Lastly, broad grading provides additional motivation as further major assessments, such as a midterm, are introduced
into the classroom environment. The study was conducted as a series of game theoretical theorems and proofs, accounting in equation for both homogeneous and heterogeneous student populations as well as uses of broad versus fine grading methods. Success of methods was gauged by theoretical effect on student motivation. The conclusion of the study was that broad grading is a beneficial practice and, furthermore, broad grading of even midterm and final scores, where those respective scores are folded into and averaged with overall scores, can create an even more beneficial outcome for the student.

Dovan and Beck (2011) took a more literal, modern approach to game theory by attempting to define the best game of four possible titles used to teach math. The authors assumed that these games had success lesson designs. They analyzed four similarly structured games for differing qualities, such as narrative or visual feedback. The participants were 297 randomly selected tutoring subjects who were divided into four tutoring groups. The four groups were each given different variants of a learning game, the variables being cooperation, competition, lack of presence of visual element. Before and after the tutoring sessions utilizing the studied games, the groups were given surveys gauging their like of the tutors, enjoyment of the subject matter, previous experience, and previous experience with the tutor overall so that the effects of the material overall could be accurately assessed. Performance on assessments was also recorded. The authors concluded that the presence of learning-specific elements in the games did not conclusively add to the learning retention of the students. Similarly, the addition of further gaming elements did not subtract from learning retention. Because of this lack of effect, the authors proposed further studies with greatly heightened learning elements so
that they would be able to further assess the direct effects of “gaminess,” or the more playful environment, on a more heightened learning setting.

**Adult Education Settings**

In adult education, the practical uses of game theory can begin even before the elements of the classroom are ever bought into play. Sawyer (2007) used a form of Game Theoretical study known as Decision Theory to analyze the usefulness of placement testing exams in defining how well students will do in a collegiate environment. Sawyer compared exam results, combined with results of the SRI (Student Readiness Initiative) questionnaire that is used to define at-risk students, to student retention in an unnamed regional university in the Southwestern United States. Once analysis yielded groupings of various grade of at-risk students, Sawyer analyzed the motivations of each group.

Sawyer concluded that better admission policies to the end of better retention in collegiate environments could be brought into place. First, colleges should use metrics to identify, but not necessarily exclude, at-risk students. Second, colleges should offer preventative measures to assist those at-risk students and inform those students specifically of advantages to availing themselves of those measures and risks of not doing so. Finally, continued study of these methods should be done to assure that the retention methods are effective.

Whereas education in the elementary and secondary schools tend towards providing knowledge of general subjects, adult education at the collegiate or corporate level tends to be highly specific and task oriented, providing a completely different set of risks and rewards for the applications of game theory. Azriel, Erthal, and Starr (2005)
analyzed the applications of game theory-based lessons in a college course by conducting a survey of students who had been newly introduced to situational games within that classroom. The survey was a Likert questionnaire that was conducted with a reversed final question to assure that the subjects were attentive in their answers. To bolster the results of the survey, a further game was provided in a review before an exam.

The results of the exam in a study group were compared with the results of an identical exam, conducted with a control group that did not receive the theoretical game review. The scores for the study group did not provide evidence for statistically significant improvement. The authors concluded that, while the exam results were not improved in a significant manner, the use of the game as an increase in motivation and a more concrete application of knowledge for the student was enough of a benefit that using theoretical games within the classroom was suggested, as was further study of possible applications and benefits to student scoring.

Further subject of the uses and applications of game theory within the classroom were done by Baker (1999) in a study of the uses of a deck of playing cards as a tool for teaching manipulatives in the entry-level college mathematics classroom. The paper was composed as a summary of research and classroom case study and provided extended historical groundwork to assure communication of the rewards and risks of a playing card deck as a mathematics education tool. After providing basis via study for the importance of manipulatives in all classrooms, the author focused on cards as a game theoretical tool within the classroom. Specifically, player motivation is gained originally through the investment and time that it takes to learn the rules of a game alone. When the rules are
learned, the players feel an obligation to themselves to play and play well that creates a sort of intrinsic motivation to complete the project. Finally, as motivations increase by all parties, the motivation of competition presents itself. Winning becomes its own reward and the game itself becomes a matter of pride and expertise to the players. While the study was done in a lack of current work on the subject of cards within the mathematics classroom, the authors posited that future research is an imperative and that silence about such a tool is the only case when it becomes less useful. However, no specific further studies were suggested.

Reese and Wells (2007) examined modern game theory for uses in the international classroom, performing a case study on an English course for international students learning the language playing “The Conversation Game,” a task-oriented educational gaming tool that provides students with situational cards to prompt discussion on a given topic. The game was taught, played, and scored in two 90 minute sessions. Reese and Wells concluded with her study of the performance of the game within the classroom and its effects on students, bolstered by interviews with students, that the use of gaming within classroom elements has potentially negative effects on student motivation. While the game provided those students who were more active and enthusiastic with an increase in those factors, it seemed to have no effect at all on those students who were not already engaged. Reese and Wells concluded that the game could be redesigned to promote participation by those less active students. For the less confident students, in particular, it seemed to them that it threw their relative skills into relief against those students stronger in English and more confident. Two other potential
pitfalls, however, were noted. Students balked at the extended amount of time that it took to learn the game that was complex, and at the time that was to be spent after the game working on scoring. Despite these risks, Reese and Wells noted that students were overall positively impacted by the games in realms of real improvement in English speaking and in confidence.

Ehrhardt (2010) analyzed the more subject-agnostic placement of game theoretical elements into adult classroom practice. Ehrhardt asked one specific question: What, if any, are the advantages that game theoretical activities over simulation activities in the higher education classroom? To answer this question, Ehrhardt conducted an analysis of the previous literature on the subject, pointing out how four types of game, The Prisoner’s Dilemma, Brinksmanship, Coordination Games, and CPR Problems, can be applied to teaching of abstract concepts in an adult international relations course. Ehrhardt concluded that international relations curriculum, in particular, had not reached a point in development where it could be integrated with game theoretical elements. Game theory would only be a distraction with the classroom because the curriculum had not evolved.

Andreozzi (2010) examined the core of game theory in an educational environment with a “Nash Demand Game,” a competitive situation where all players are competing for a piece of a predefined, limited prize. This study was a theoretical analysis of present literature on three subjects: (a) game theory, with specific concentration on Nash Demand Games, (b) game theory with specific concentration on Produce and Divide games, and (c) the effects of the uses of both of these tools in an analytical, adult
educational setting. The analysis concluded that using Produce and Divide (PAD) model provides less egalitarian and therefore more realistic outcomes of learning games. However, the conclusion provides a warning as well. Not all PAD models, because of the lack of necessarily egalitarian outcome, will have a positive effect on the learning environment. Andreozzi recommended further study into the active use of PAD models in the adult classroom and precisely how they can used to simultaneously create the lack of egalitarian outcome while still requiring egalitarian input, thereby creating an equitable experience, if not a positive one, for all students. One suggested form was one where, while the outcome is not equal, the outcome is openly negotiated, as is the division of input or labor.

Previous studies surveyed have centered on uses of game theory specifically within a classroom structure and surrounding the tools of interaction between student and teacher. However, specifically in the realm of higher education, game theory can be further applied to many aspects of educational structure and bureaucracy. Klaus and Klijin (2007) applied the models of game theory to the process of student placement. The authors used an expansive definition, noting that “student placement” can refer to position in a “house,” (a cohort students defined by a common thread in educational practice and, in some cases, actual proximity of physical residency) or a class or any position that can be filled by the student. The dynamics of cooperation and competition for student placement become more evident when the preferences of the student are observed. The second tier of cooperation and competition becomes evident when the motivations of pairs of students who can be described as “couples” are observed. The
authors hypothesized that a method of student placement, regarding couples, could only be both fair and effective if the togetherness of a couple is taken into the priority structure of the selection method, alongside other priorities, such as student performance, position preference, and position feasibility. Through a traditional game theoretical analysis, based both in humanistic theory and in statistical analysis, the authors came to several conclusions. First, it is possible to weight placement of couples in a fashion that can still be judged as fair to the common eye. Second, there must be a threshold when the performance of the couples is “close enough” (p. 183) to allow the students to be placed in the same group despite a possible deficiency in the performance of one party. Conversely, that threshold must be respected and there must be a point when the togetherness of couples is not allowed so that fairness is preserved. Finally, the threshold when togetherness is deprioritized must increase in direct correlation with the most qualified student’s qualifications for placement within the group.

In a critical and technical analysis that spanned all levels and types of education, Hood (1997) provided a wide-ranging summary of pitfalls and advantages of four classified theoretical games. The four classes that Hood provided were Gaming, Role-Playing, Simulation, and Modeling, with a spectrum that defines the four with specific scope. Using those definitions, Hood noted that gaming is the oldest of the four forms, wherein rules are dominant over roles and minimal inference is required on the part of the players to perform. The author provided the optimal game situation, wherein the task is paramount and critical thinking is either irrelevant to game outcome or, at other times, detrimental. Conversely, overuse of the game can be detrimental to a real-world outcome.
where critical thinking is an advantage, noted the author, as well as in situations where real world situations may require differing strategies or costs for game implementation are prohibitive. Simulations are an opposite of gaming. They can provide adult learners with a foundation for further research and formulation of new ideas and techniques as well as a baseline for critical thinking. Because of this motivation towards and need for abstraction, however, the simulation is not as useful for younger learners as it is for adult learners. Modeling and role-playing are the two final forms of simulation wherein, respectively, either the player fills a predefined role by copying it, requiring little to no critical thinking due to strict rule structure but high inference, or the players fill multiple generally defined roles and predict interactive elements, requiring low inference due to generality of rules but high critical thinking due to prediction of interaction and other student motivation.

Each description of a game type was accompanied by a short case study of the type. This provided a real-world application of each type as well as a basis for further examination. In the conclusion, the author predicted that the digital revolution would significantly change the use of simulation, both allowing it to move further into the abstract and significantly decreasing the costs of implementation of all gaming types. Further study into the use of each type in an educational environment and its effect upon the student population and learning ability was suggested.

While the primary focus of adult education is in the academic or corporate setting, one element of adult education has been mostly unexplored by way of game theoretical tenets. Eggleston and Gehring (2000) used game theoretical rules to perform a critical
analysis of the uses of a democratic system in correctional education (CE). The goal of the study was to analyze the use of a democratic educational plan to provide inmates of a correctional institution with a degree of maturation as they progressed so that they might be ready to reenter society. A democratic educational plan was defined for the study as one that focuses on shared responsibility, decision-making, and recognition for actions performed within the classroom setting. The use of the plan was analyzed specifically with tenets of game theory, analyzing the motivation of the inmates to cooperate or compete with an instructor as well as to cooperate or compete with each other within the democratic plan, in comparison to a traditional educational plan. The conclusion of the critical analysis was that in most cases, the application of a democratic educational plan resulted in dramatic growth in the students who the plan was applied to. No further study was recommended.
CHAPTER IV
CRITICAL ANALYSIS OF THE LITERATURE

An analysis of the literature that forms a foundation for the uses of game theory in education becomes inherently complex. The majority of the analyzed studies used game theory as a baseline for the testing of other factors within and around the classroom, be it a potential humanistic dynamic that is directly analyzed with the tenets of game theoretical thinking or the effects of a new classroom dynamic on student motivation. The applications of game theory are by their nature indirect, excluding applications where the material of a given lesson is game theoretical. Because of this sidelong nature, each study, excluding those wherein the direct applications of game theory to classroom are analyzed, is assessed based on its uses of game theory as a tool to analyze and improve classroom dynamic.

Development of Educational Materials and Planning

There are numerous possible applications and pitfalls of game theory to the implementation of educational materials and lesson planning (Table 1). Game theory can be used to analyze games for skill acquisition goals and their impact on student
motivation (Wilson, et al., 2009). When applied to overall lesson design, game theory can assist instructors in developing materials and planning lessons that motivate the teacher as well as the student (Shelton & Scoresby, 2011). In increase in student motivation as result of the implementation of game theory (Burguillo, 2010) is likely to result in an increase in overall classroom performance and engagement (Baker, 1999; Huang, Huang & Tschopp, 2010).

In addition to the impacts on student motivation and, therefore, the outcome of designed lessons, game theoretical elements also help students to contextualize information gained within educational practices (Abrams, 2009). Despite the evidence for the gains to be had from inclusion of games in lesson design, other sources noted a lack of correlation between inclusion of games and any gains in educational achievement (Azriel, Erthal, & Starr, 2005; Dovan & Beck, 2011) or a detriment to students who may already be suffering (Reese & Wells, 2007). Reese and Wells also provided ample evidence for enrichment opportunities for already successful or engaged students as well as results of overall success in increasing achievement, despite the aforementioned risks.

In addition to the effects on student motivation and achievement, game theory can also be used to gauge the usefulness of specific methods and schools of curriculum design as well as their effects on student and teacher motivation (Stull, 2004). The most successful games will factor teacher motivation (Kebritchi, 2010) and will also note that student motivation alone will not increase performance (Wang & Chen, 2010).

In adult and higher educational fields, game theory can be used on conjunction with active task simulation to de-abstact classroom concepts and create a real and
intellectual tie to life situations. It is important to recognize, however, that the potential field of application for game theory must be judged carefully, as the inept inclusion of a game into educational environment can be a detriment to classroom culture and educational outcome (Ehrhardt, 2010).

**Learning Assessment**

Game theory and learning games can be used to convert states of summative assessment to states of formative assessment and increase educational outcomes (Cotton, Ahmadi, & Esselborn, 1997) (Table 2). When successfully applied, game theoretical assessment tools will create an increase in motivation for both student and teacher as well as a major increase in student success (Dubey, 2010).

Once the application of games as formative assessment are understood, assessment games can then be chosen by outcome and applied to student learning need and, for the younger student, to behavioral skills as well (Wilson, et al, 2009). Not only can assessment games organized by outcome be used to a strong positive effect on the student, but they can also be applied in a fashion that increases student motivation and even excitement about upcoming assessments (Wang & Chen, 2010), creating an increase in the positivity of the classroom environment. To further motivate students in realms of assessment, competitive games can be used (Burguillo, 2010), but caution should be exercised, as competitive games have been shown to have a possible detrimental effect on the students who may be at the lower end of the scale in achievement and engagement (Reese & Wells, 2007).
Classroom Activity

Classroom activity holds the broadest application for game theory, ranging from before the student ever enters the classroom to long after the student returns home (Table 3). Game theoretical practices can be used to place students in groups, such as classroom, cohort, or even college for maximum educational outcome, taking into account a myriad of factors such as student motivation to compete and grow within a given environment (Sawyer, 2007) and even student pairs, wishing to get into the same group (Klaus & Klijin, 2007).

Within the classroom environment, Ferguson (1971) provided warnings about the applications of game theory, noting a lack of concerns with educational goals or ability to account for multiple players. Despite this, other game theorists have created models to account for multiple players and apply them (Luce & Raiffa, 1957), allowing for broad applications in an educational field as long as goals are accounted for. Game theoretical analyses to assess classroom dynamics can be used for many situations, such as summer-camp styles of learning, led by peers (Sanford & Madill, 2007) as well as more acute factors in classroom environment, such as the motivations and risks of players within the classroom to exhibit caring in regards to a specific situation (Slater, 2004).

When applied to younger generations of the learner, the products of the “digital learner” generation, game theoretical elements gain even more potential and become even more important (Hood, 1997; Divjac & Tomic, 2011), but Divjac and Tomic note that lessons must still be first pedagogically designed to provide the greatest benefit for the student.
Games can also be used to assess specific forms of classroom dynamic. Elstad used game theory to assess dynamics of undirected students or of lack of consequence (2002) and then to assess an intentional Lessaiz Faire classroom (2006). Beyond applications of nontraditional or non-ideal educational dynamic, game theory can also be used to assess classroom dynamics completely outside of educational fields, such as a corrective dynamic (Eggleston & Gehring, 2000).

After the student has left the classroom, the applications of game theory do not end. Motivations of student, parent, and educator each play a role in the educational environment, as do their effects on each other (De Fraja, Oliveira, & Zanchi, 2008) and can be analyzed in game theoretical terms to provide predictors of reaction and outcome, providing teachers with further tools for the prioritization of action and overall increasing educational efficacy.
Table 1

*Game Theory in the Development of Materials and Planning*

<table>
<thead>
<tr>
<th>Author and Year</th>
<th>Purpose</th>
<th>Application to game theoretical uses in materials and planning</th>
</tr>
</thead>
<tbody>
<tr>
<td>Abrams (2009)</td>
<td>Study the usefulness of game theory in assisting students to contextualize lesson information.</td>
<td>Learning games can help students to contextualize and apply lesson content to themselves and real life.</td>
</tr>
<tr>
<td>Azriel, Erthal, &amp; Starr (2005)</td>
<td>Study the applications of game-based learning in collegiate study.</td>
<td>Game lessons do not meaningfully increase achievement; however, they do increase student motivation.</td>
</tr>
<tr>
<td>Baker (1999)</td>
<td>Find the advantages and applications of playing cards and other manipulatives in the mathematics classroom.</td>
<td>Learning games increase student motivation by investment in activity and through competition.</td>
</tr>
<tr>
<td>Burguillo (2010)</td>
<td>Assess the use of several competition-based games and their effects upon classroom environment, motivation, and achievement.</td>
<td>Competition-based learning can provide extra motivation to reach goals in a learning setting, especially when learners are made aware of extrinsic motivations.</td>
</tr>
<tr>
<td>Dovan &amp; Beck (2011)</td>
<td>Find the best of four possible games in mathematics education.</td>
<td>Games have no meaningful impact on student achievement.</td>
</tr>
<tr>
<td>Ehrhardt (2010)</td>
<td>Study whether games can be</td>
<td>The incorrect use of a game for educational purposes can be</td>
</tr>
<tr>
<td>Source</td>
<td>Study Description</td>
<td>Findings</td>
</tr>
<tr>
<td>--------</td>
<td>-------------------</td>
<td>----------</td>
</tr>
<tr>
<td>Huang, Huang &amp; Tschopp (2010)</td>
<td>Assess the results of online-based game education on motivation and outcome.</td>
<td>In online-based game models used for education, motivation has a direct correlation with improved outcomes.</td>
</tr>
<tr>
<td>Kebritchi (2010)</td>
<td>What are the risk factors of game theoretical integration from the perspective of the teacher?</td>
<td>Teacher enthusiasm in the integration of a learning game is a key factor in the academic successes of that game.</td>
</tr>
<tr>
<td>Reese &amp; Wells (2007)</td>
<td>Study the impacts of a learning game on an English course for international speakers.</td>
<td>Games cause motivated and achieving students to become moreso and unmotivated and underachieving students to become moreso as well but have an overall positive effect on student confidence and achievement.</td>
</tr>
<tr>
<td>Shelton &amp; Scoresby (2011)</td>
<td>Study the uses of games in the goal-oriented classroom and find specific game types that are more successful in that goal.</td>
<td>Classroom games increase teacher motivation, but their effects on classroom success are unclear.</td>
</tr>
<tr>
<td>Stull (2004)</td>
<td>Study the effects of integrating vocational and academic curriculum in a high school environment.</td>
<td>Game theory can be used to gauge effectiveness of curriculum methods as well as impacts on motivation achievement.</td>
</tr>
<tr>
<td>Wang &amp; Chen</td>
<td>Assess the uses of learning games</td>
<td>Learning games can be tailored to be effective.</td>
</tr>
<tr>
<td>(2010)</td>
<td>game theoretical models in a complex, task-oriented school environment.</td>
<td>increase learner motivation or learner achievement.</td>
</tr>
<tr>
<td>--------------</td>
<td>--------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Wilson, et al (2009)</td>
<td>Match theoretical games with their outcomes and organize and assess their efficacy in achieving those outcomes</td>
<td>Game theory can be used to assess classroom material by effect on motivation as well as learning target.</td>
</tr>
</tbody>
</table>
Table 2  
Game theory in Learning Assessment

<table>
<thead>
<tr>
<th>Author and Year</th>
<th>Purpose</th>
<th>Application to game theoretical uses in assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Burguillo (2010)</td>
<td>Assess the use of several competition-based games and their effects upon classroom environment, motivation, and achievement.</td>
<td>Competition-based learning can provide extra motivation to reach goals in a learning setting, especially when learners are made aware of extrinsic motivations.</td>
</tr>
<tr>
<td>Cotton, Ahmadi, &amp; Esselborn (1997)</td>
<td>Study the applications of game theory in quality assessment and learning for average students preparing to enter a professional workforce.</td>
<td>Educational games have much potential to be useful, but should be judged carefully on their utilization, potential for skill-building, and application to the subject at hand.</td>
</tr>
<tr>
<td>Dubey (2010)</td>
<td>Study the advantages and disadvantages of broad grading and assessment methods in the classroom.</td>
<td>Game theory can be used to test the efficacy of testing methods and their impacts on student motivation and success.</td>
</tr>
<tr>
<td>Reese &amp; Wells (2007)</td>
<td>Study the impacts of a learning game on an English course for international speakers.</td>
<td>Games cause motivated and achieving students to become moreso and unmotivated and underachieving students to become moreso as well but have an overall positive effect on student confidence and achievement.</td>
</tr>
<tr>
<td>Wang &amp; Chen (2010)</td>
<td>Assess the uses of game theoretical models in a complex, task-oriented school environment.</td>
<td>Learning games can be tailored to increase learner motivation or learner achievement.</td>
</tr>
<tr>
<td>Wilson, et al (2009)</td>
<td>Match theoretical games with their outcomes and organize and assess their efficacy in achieving those outcomes.</td>
<td>Game theory can be used to assess classroom material by effect on motivation as well as learning target.</td>
</tr>
<tr>
<td>Author and Year</td>
<td>Purpose</td>
<td>Application to game theoretical uses in classroom activity</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------</td>
</tr>
<tr>
<td>De Fraja, Oliveira, &amp; Zanchi (2008)</td>
<td>Examine the uses of Nash Equilibrium in educational practice.</td>
<td>Effort put out by schools can have a negative impact on students, whereas effort by student and parent both have a positive impact on the other.</td>
</tr>
<tr>
<td>Divjac &amp; Tomic (2011)</td>
<td>Assess the impacts of digital learning games on motivation and outcome.</td>
<td>Gaming education has a positive effect on the realization of educational goals, motivation, and educational outcome.</td>
</tr>
<tr>
<td>Eggleston &amp; Gehring (2000)</td>
<td>What are the effects of a democratic classroom system on correctional education?</td>
<td>Game theory can be used to assess alternative classroom dynamics and their effects on motivation and behavioral outcome.</td>
</tr>
<tr>
<td>Elstad (2002)</td>
<td>Study the motivations of students in a classroom where consequence or goal are absent.</td>
<td>When alternative classroom dynamics are applied, game theory can be used to gauge their effects on student and teacher motivation.</td>
</tr>
<tr>
<td>Elstad (2006)</td>
<td>Study the effects of a non-goal oriented classroom or one absent of rules on student motivation and success.</td>
<td>In a classroom without traditional motivations, game theory can be used to assess those motivations, mitigating factors, and ways to cope with them and achieve maximum educational success.</td>
</tr>
<tr>
<td>Ferguson (1971)</td>
<td>Assess the effects of game theoretical teachings on a social</td>
<td>While it has specific applications, game theory is mostly inadequate for</td>
</tr>
<tr>
<td>Reference</td>
<td>Description</td>
<td>Applications</td>
</tr>
<tr>
<td>------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Hood (1997)</td>
<td>Study the effects of four types of learning game on classroom environment and their best applications to education.</td>
<td>Games can be organized by lesson type, need for critical thinking, and learning target for maximum usefulness.</td>
</tr>
<tr>
<td>Klaus &amp; Klijin (2007)</td>
<td>Define the uses of game theory in student placement.</td>
<td>Game theory can be applied to education even outside of the classroom, assessing student motivation in regards to placement.</td>
</tr>
<tr>
<td>Sanford &amp; Madill (2007)</td>
<td>Study the uses of games in literacy education and in a peer-as-educator environment.</td>
<td>Games in the peer-led literacy education environment can improve motivation for instructor and student as well as student achievement.</td>
</tr>
<tr>
<td>Sawyer (2007)</td>
<td>Gauge the usefulness of placement tests in predicting student success in a collegiate environment.</td>
<td>Game theory can be used to assess success of placement strategies and their effects on student motivation.</td>
</tr>
<tr>
<td>Slater (2004)</td>
<td>Study the effects of caring in the classroom, using game theory and the works of Lao Tzu as a baseline.</td>
<td>Game theory, while inherently complex in its applications to interpersonal dynamics, can be used to assess simple and isolated classroom dynamics and their effects upon individual motivation.</td>
</tr>
</tbody>
</table>
CHAPTER V
CONCLUSION

For elementary school teachers, these findings have provided a clear directive. Regardless of rationale or number of players, the use of a game theory in education as a method of thinking and planning can greatly increase classroom effectiveness by bolstering the motivation of students and teachers in classroom tasks. While this potential benefit is great, uses of game theory in the elementary situation must be tempered by a lack of assumption.

While a nearly overwhelming amount of evidence points towards benefits of game theory in the elementary classroom, Ferguson’s (1971) dated but still relevant warning is of vital importance. Teachers must be wary that younger children, while possessing their own motivations to engage in games, are often irrational and, therefore, must be judged by their motivations, not of the adults’. Similarly, when games are used, more than interpersonal dynamics appear in any educational environment and all must be accounted for so that any game theoretical model can be useful within the classroom. For example, a two-person game dynamic such as Nash Equilibrium cannot be applied equally to students in situations where students have opportunities to both cooperate and
compete with each other and the teacher, such as group competitions or even a dynamic when a bully and victim are present. More complex games must be utilized in such situations.

In secondary classrooms game theoretical learning can take an even greater part in education. In elements of grouping and planning, such as in accelerated courses, student grouping can become more significant with game theoretical analyses of student motivation and success factors rather than simply grade performance. In secondary classrooms, game theory can begin to take an overt role, wherein students can participate in situational games that take learning out of the realm of the abstract and into the realm of practice. Teachers become more focused by subject and can use game theoretical models to analyze dynamics of discipline, of task, and of goal, and even of subject concentration to optimize the classroom environment and provide motivation for students to perform at their maximum potential. In addition, game theory can enhance the competitive nature of the secondary classroom, provide students with further motivation for performance, and provide teachers with the best timing for use of competition in the classroom and, just as importantly, when not to employ it.

The environment of adult education is the first where financial transaction is factored into student motivation, either as tuition or potential income offered within the classroom. Furthermore, adult education in a vocational environment focuses firmly on tasks and goals, thus creating new potential for game theoretical study. Before students enter the classroom, teachers can apply the same game theoretical applications to
grouping students to assess success factors but also the motivation of pairs of students.

Game theoretical tactics can strengthen vocational and academic environments.

It has been shown overwhelmingly that games strengthen the motivation of adult students just as they do for their younger counterparts. Games provide a method for the direct application of lesson topics to tasks, real world situations, and dynamics, rather than in the abstract. While expanding game-based learning creates an overall benefit within the classroom, risks arise for those students who may already lack motivation or performance concerns, and thus, should only be used in optimal conditions where teachers work with motivated group of students, such as in vocational environments.

The use of game theoretical practices in higher education is not always appropriate, however. Sometimes, it is important to focus on using simpler and more traditional learning games such as task simulation, rather than focusing on the motivational aspects and interpersonal study inherent in theoretical games. Theoretical games must fit the situation so that the theoretical game is directly tied to the learning goals.

Closing Thoughts

A myriad of resources have been presented showing the applications of game theory at all educational levels, and in several educational fields, from the traditional elementary school classroom to the correctional facility to the strict environment of corporate training. While there are risks in application of game theory across the board, the rewards in student and teacher motivation and in retention of lesson information merit use of game theory across the educational spectrum. For the teacher, this represents a new
philosophy and tool that will assist clear thinking and planning to include all motivations and use them to achieve the greatest educational outcome.

Assessment is the least studied subfield in this regard. Research on the effects of open game theoretical use in assessment tools that compares traditional formative assessments and game theoretical assessments at all grade levels is recommended.

Ultimately, the adaptation of game theory to improve the educational world comes in asking teachers the question that so many students have already answered: Are you ready to play?
REFERENCES


doi:10.1080/09523980903387480


doi:10.1016/j.compedu.2010.02.018


Polytechnic Institute, Worcester, MA.


video game play and design, *Canadian Journal of Education*. Ottawa: Canadian Society for the Study of Education. 30(2), 432-455


doi:10.1177/1046878108321866