DOES LEARNING OCCUR IN ONE-SHOT, NON-COOPERATIVE GAMES?

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ABSTRACT

Learning to learn is a basic foundation of life and necessary for evolution. The ability to show the existence of learning can at times be difficult in one-shot, non-cooperative games. The ability to transfer knowledge from one situation to another is an indication of how much one actually learns and how it is applied. The purpose of this paper is to show the existence of learning in this type of game by using the vertical checkers game "Connect 4". By looking at the difference in won-loss records between two tournaments and the distribution of the scores, we can show that learning has occurred when teams have a greater degree of parity and that average number of wins increases as the range of wins decreases.

INTRODUCTION

Learning to learn is a basic foundation of life and how we learn helps us in not only the acquisition of knowledge but also in our basic outlook on life. It can be further stated that how we learn can increase the amount we do learn and retain both as children and as adults. We too often accept the idea that the child (one) learns while playing, often overshadowing the learning modalities specific to each situation the passage from the play experience in its singularity to learning content is sometimes very mysterious; resource to the critical references can have a magical aspect that keeps us from addressing the problem in its singularity (Brougere, 1999). The child, particularly in collective situations, progresses in his or her mastery of a game, and therefore, by playing, learns to play better and better (Brougere, 1999)

According to John Beck, president of the North Sea Leadership Group and senior researcher found that there are certain characteristics of game players (regardless of age) that are very welcome in the workplace: gamers are more sociable, they like to win and believe that winning matters; they are competitive and loyal and they have a broad perspective and strong analytical skills. This coincides with their learning style in the following areas: they ignore formal instruction; rely almost exclusively on trial and error; they incorporate learning from peers rather than authority figures; and, operate through the absorption of knowledge in very small increments, usually before they need it (HRFocus, 2007).

Childhood is the period of time during which we learn to play and when we progress in the mastery of this activity. Learning to play is learning to master situations marked by necessary meta-communication (Bateson, 1973). Mastery of a game therefore would imply mastery of the rules of the game in both understanding and in application in the game. Learning is then shown through how the game is played and its impending result.

Justification in using games to learn is seen to include; as having the ability to translate the complexity of situations by highlighting the interdependence of factors and actions; evoking for its concrete dimension, the construction of an experience in which general and abstract knowledge may be put into play; and, the need to put emphasis on the necessity for the player to solve problems, act, decide, and be creative (Guide Edilude, 1995). So the question becomes, can we learn anything from playing games and how we show that learning has occurred? Can we learn through experience directly or through work that appears, among other things, during its debriefing (Brougere, 1999)?

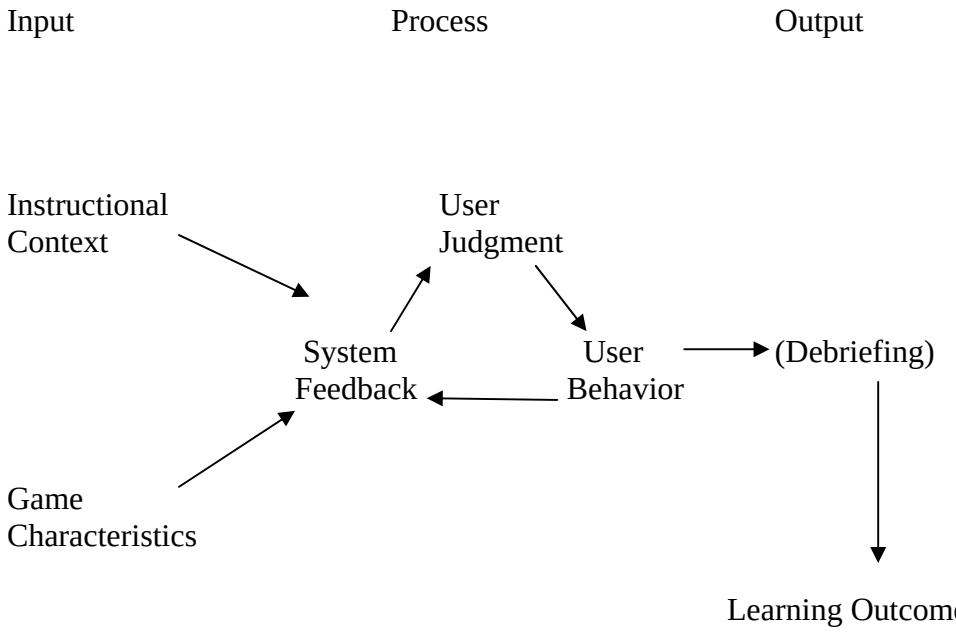
Many consider debriefing to be the most critical part of the gaming experience (Crookall, 1995). Reflection is found in the debriefing and is required to make transfer and learning possible. Thiagarajans' (1993) proposed that there are three phases in the process: experience → reflection→ learning. Experience may be present due to various natures such as role-playing. Reflection involves the transfer to a state of generalization, to analysis of action, alternatives, feelings, etc. and can be considered to be self-debriefing. The critical point is that reflection enables the passage from play to learning, and therefore an important or essential contribution to research on play and gaming in education.

Debriefing provides a link between what is represented in the gaming experience and the real world (Garris, 2002). Learning then comes in the association process (the drawing of similarities between the worlds) in the application in the real world.

What characterizes gaming in adult education is its inclusion in a formal and intentional training process where, if the game is in a less formal phase, it is, part of a conscious educational project. A study conducted by Gartner in 2006 predicted that "game-based learning can significantly accelerate the transfer and the application of knowledge". Games are also powerful when; games are motivational, keep people interested and learning for longer; provide the opportunity to learn in a competitive and social environment; and, lastly when they provide a "real-time" instantaneous feedback (HRFocus, 2007). Lastly, it was found that the effectiveness of game-based training is dependent on the nature of the game itself, on what is being taught, and whether the learning "fits a cognitive taxonomy" (HRFocus, 2007).

The traditional game cycle (Figure 1) emphasizes single trial learning, where a learner performs a task over a single trial. However the key component is the *game cycle* that is

FIGURE 1
Input – Process – Outcome Game Model



triggered by specific game features. A central hallmark of game play is not that users play a game and then put it down but that users are drawn into playing the game over and over (Garris, 2002) . It is in the repeated playing of the game and the feedback generated from knowledge acquisition and transfer that leads to learning. How much is learned through experience and knowledge transfer is going to depend on the group's intra-action and dialogue within the group during the course of play. In this case the outcome is knowledge in the application in the Rules of Strategy.

It is thought that only teams can experience positive learning transfer between games due to the pooling equilibria that enhances the adjustment to the separating equilibrium (compared to teams with no experience). This is compared to individuals who have experience in the game with pooling equilibria retards adjustment to the separating equilibria following the change in games, so that there is negative learning transfer. A question that is begged at this point is that you can have negative transfer exist in teams also if the teams fail to properly apply the given knowledge on its combined memory (Cooper and Kagel, 2005)

THEORETICAL FOUNDATIONS

The manner in which a person uses their cognitive skill has an effect on how that person goes about learning. The same can be said of how teams go about in their learning. Prior research by Micklich (2006) showed the existence of some degree of learning through an application of the Thinking Steps Model of game theory by applying it to the vertical checkers game "Connect Four". This model is designed to predict behavior in one-shot games and also to provide initial conditions for models of learning (Camerer, 2001). The question was asked at that time, how does one know that learning has truly occurred in a game and how can it be substantiated in subsequent games. In his research he stated that teams gained knowledge as the games progressed and that this constituted learning. That is, can this knowledge be transferred from one game series to the next from within a series of games and between a series of games and how this can be best illustrated?

There has been very little evidence where a game is played multiple times and end scores of each game are compared with the prior series or games. In the realm of game theory, information acquisition is crucial in determining the amount of information that can be put into memory and later retrieved and transferred. This acquisition is also crucial to resolving the question of whether the players are close to equilibrium or some sort of parity over time. This stems in part from belief learning which in turn affects strategic thinking or how we play the game. In belief learning, players do not learn about which strategies work best, they learn about what others are likely to do, then use those updated beliefs to change their attraction and hence what strategies to choose (Fundenberg and Levine, 1998).

How one learns and how one transfers that learning is a function of the acquisition of their cognitive skills and how they apply those skills. Fitts (1964) stated that the process of skill acquisition falls into three stages of development cognitive, associative, and autonomous stages. Anderson (1982) reduced these stages into two; declarative, in which facts and figures about the skill domain are interpreted; and, procedural, in which the domain knowledge is directly embodied in procedures for performing the skill. In the declarative stage (Fitt's cognitive stage), verbal mediation is frequently observed because the facts have to be rehearsed in working memory to make them available for the

interpretative procedures. In terms of the game, team members would discuss among themselves the rules of the game, by which they would govern themselves during play, and various configurations of checkers to be on the watch for. To these two stages, two more need to be considered, strategic knowledge and affective learning outcomes.

According to Anderson's theory, Fitt's second stage, associative, is actually a transition between the declarative stage and the procedural stage. The process by which the knowledge is converted from the declarative to the procedural form is called knowledge compilation (Fitts's associative process) (Anderson, 1982).

The exhibition of procedural knowledge and in this case an execution of a move is based on what he calls "productions". A production is defined as "a primitive rule that specifies a cognitive contingency, that is, a production specifies when a cognitive act should tale place" (Anderson, 1982). This production has a condition that specifies that circumstances under which the production can apply and an action that specifies what should be done when the production applies. The sequence of productions that apply in a task corresponds to the cognitive steps taken in performing the task (Anderson, 1982).

In terms of the study, individual productions can be thought of as the individual thought processes which lead to either a move or a series of moves. These moves will in turn lead to certain actions being performed when a specific condition exists. The specificity of the existing condition will lead to either the move being made in general or in specific. For example, if the goal of a particular course of action is to place checkers in a diagonal, or if the goal is to place the checker in spot "A". Given the specifics of the situation, the action would be to place the checker in spot "A", given that "A" is on the diagonal. Furthermore, a more specific production will take precedence over a more general production only if its selection time is less than the selection plus application times of the more general production (Anderson 1982). In other words, in some cases, the players' response will be by rote to a given situation, hence lessened selection time associated with a specific situation as opposed to a lengthened selection time given a more general situation.

This is what is called strategic knowledge. Strategic knowledge requires applying learned principles to different contexts or deriving new principles for general or novel situations (Garris, 2002). This would also be where new strategies or sequences of strategies would be realized. Affective learning outcomes derived from this process may be viewed as a specific type of learning outcome to the extent that attitude change is a training objective of an instructional program (Garris, 2002) In terms of this study, it occurs during the self-debriefing when the questionnaire is completed at the end of each game.

Knowledge compilation is important because its process results in the recognition of rivals' courses of action and their effect. In the execution of these courses of action errors can take place in which the wrong course of action is applied. These errors result from a team trying to recall what was done in prior situations and trying to apply the appropriate action to the situation only that the application itself may be wrong. As Anderson puts it; "Students can be seen to repeat themselves over and over again as they lose critical intermediate results and have to recomposite them. That is, they would tend to execute the same action (strategy) hoping that different results would be realized each time. (This is also a definition of insanity) Additionally, they aren't initially choosing a particular course of action because they incorrectly anticipate that it would led to favorable (different) responses, but rather they fail to consider that their choice will have an impact on their rivals' responses (Cooper and Kagel, 2005).

Given the lessening of selection time of courses of action, we can infer that some sort of procedure then exists. This part of the process called, "proceduralization", builds versions of the productions that no longer require domain-specific declarative information to be retrieved into working memory. In other words, the players/teams exhibit again, reaction by rote. This type of reaction increases the possibility that teams can perform tasks, such as also looking toward the next response, while still performing the rote response. What must be considered under caution is that one may move too quickly in the declarative → associative → procedural process thereby increasing the probability of mistakes being made. These mistakes can also stem from trying to put too many combinations of moves and developing a preference for that sequence of moves within an overall action (strategy) and the proper sequencing of the moves or from an inability to try new things.

It was stated earlier that the compilation process is, in general, slow, gradual, and occurs as a result of practice. Anderson (1982) further states that humans do not know what is going to be procedural in an instruction until he or she tries to use the knowledge in instruction. In terms of strategy, until we try and experience a series of moves and its effects, we cannot begin to put it into a set course of action or make it an actual part of that action (strategy). Additionally, the ability to recognize failed sequences attempts which may contribute to an overall less successful or failed strategy. The ability to make adjustments to strategy will depend largely on the degree of learning transfer that is present. In many psychological experiments there is little or no learning transfer unless the subjects (teams) are explicitly queued to draw on their previous experiences (Solomon and Perkins, 1989).

The ability to take what we have determined to be action (procedural) and to fine tune it, i.e. make adjustments, relates to the experience one has accumulated over the process. It is important to note at this point that even though one would have a great deal of knowledge in a particular area, does not mean that one possess experience in that area. Experience that one has is gained through the association process together that ties together the various and separate knowledge points which exist. These knowledge points are similar to what Cooper and Kagel (2005) defined as an "aha" type of insight. This type of insight is where one team will realize that their action will affect their rivals' action beliefs and by extension, their

rivals' choice of responses. In this case we have the existence of "eureka" problems. This type of problem has a correct solution (or solutions). While this solution may be difficult to discover, through trial and error, and reasoning back, it is self-confirming once discovered and can easily be demonstrated to others, assuming that each series of moves is a small problem in itself.

If this is true, then the movement from one small problem to the next can be also seen as a series of "aha" moments as these would lead to the overall "aha" of actually winning the game (eureka – I/We did it!). This would be a result of intragroup interaction where the individual members' "aha's" would be evaluated by the group and a consensus made for the chosen "aha" to be played. Depending on the rivals' response, this "aha" also has the possibility of becoming an "oh-no" insight with a negative connotation.

In teams where group interactions are important, we can see evidence that over time superior performance should result against other teams. This is of course dependent on the degree of learning that has taken place over that period of time. Marjorie Shaw (1932) observed freely interacting four person groups working on word puzzles. She found that in most problems both the proportion of solutions and the time to find a solution was superior for groups than for individuals. This is a typical result when comparing groups and individuals directly, a result attributed to the ability of group members to catch others' errors, reject incorrect solutions, and generally stimulate more thoughtful work (Davis, 1992). The ability to do this depends again on the amount of learning transfer which takes place.

Lorge and Solomon (1995) proposed the truth-wins (TW) standard against which to evaluate the superiority of group's performance. Assuming that group interactions are neutral, the group should be able to achieve a correct answer if at least one member proposes it (i.e. one person that has the "aha" moment). While this may be true, another question poses itself and this one is concerning intragroup interactions. The dialogues which occur within the team will also give an indication of the degree of learning transfer and the existence of the TW standard, if truly shared. It could be argued that positive learning transfer (knowing when a particular course of action will not work and when

EXHIBIT 1
MQM 385 Organizational Strategy
Connect 4 Tournament 1
Spring 2007

Winner:

Your Team

vs.

Your Rival

For each round please complete the following:

1 Who made the first move? Did you see this as being an advantage?

2 Describe in detail the strategy you used to start the game

3 Describe in detail the strategy you used in the middle of the game

4 Describe in detail the strategy you used toward the end of the game

5 At any point during the game, did you find yourself changing your strategy? If so, in what way did it change?

6 During the game were you able to envision your strategy and try to get your rival to move in that direction?

7 At any point in the game, did you wish you could take a specific move back? If so, at what point in the game would you want to take it back?

8 During the game would you describe your overall strategy as one of passiveness, moderate aggression, or very aggressive?

9 What did you learn?

EXHIBIT 2
MQM 385 Organizational Strategy
Connect 4 Tournament 2
Spring 2007

Winner:

Your Team

vs.

Your Rival

For each round please complete the following:

1 Who made the first move? Did you see this as being an advantage?

2 Describe in detail the strategy you used to start the game

3 Describe in detail the strategy you used in the middle of the game

4 Describe in detail the strategy you used toward the end of the game

5 At any point during the game, did you find yourself changing your strategy? If so, in what way did it change?

6 During the game were you able to envision your strategy and try to get your rival to move in that direction?

7 At any point in the game, did you wish you could take a specific move back? If so, at what point in the game would you want to take it back?

8 During the game would you describe your overall strategy as one of passiveness, moderate aggression, or very aggressive?

9 What did you learn? Can you draw any comparison to the first part of the tournament

to change) is likely to be difficult since this action behavior following this crossover (before to after) requires substantially different actions than before the crossover (Cooper and Kagel, 2005). In other words, a rival will tend to play a "monkey see – monkey do" (imitation strategy) but then after the crossover must differentiate itself from its rivals.

From this we can formulate the following hypotheses:

Hypothesis 1: There will be an existence in knowledge transfer from one round to the next between one team and its rivals (inter-group learning).

Hypothesis 2: We should see a greater evidence of knowledge transfer as teams move toward greater parity in won-loss records (intra-group learning).

METHODOLOGY

The vertical checkers game "Connect 4" was used in a round-robin tournament format. The tournament was conducted on two separate occasions with a one-week period between tournaments. There were 9 teams of 2-4 people each participating. They were instructed that as they played to game to keep in mind the rules of strategy outlined by Dixit and Nalebuf (1999). These are briefly: to look ahead and reason back in calculating your best move; if you have a dominant strategy, use it; eliminate any dominated strategies from consideration; and, finally, having exhausted avenues of looking for dominant and dominated strategies, look for an equilibrium to the game, in other words a tie.

The students were also asked to complete a questionnaire (Exhibit 1) after each round and indicate who the winner was. The questionnaire for the second round was similar to that of the first round with the following exception: the last question had the following added to it:

Can you draw any comparisons to the first part of the tournament? This question was designed to gather data about play from the first part and could any new insights be gained due to play from the first part, carried over to the second. The won-loss records from each tournament are shown in Table 1, as well as the place finished. Table 2 shows the distribution of wins-losses has become more compact. The mean number of wins in the first tournament is 3.2 with a mode of 3 and a range of 7. The mean for the second tournament is slightly higher at 3.7 wins with a mode of 3 and a range of 6. This gives an indication of intergroup learning where one group uses the experience of play. It stands to reason that if this knowledge were not used that the won-loss records of the second tournament would be similar to that of the first. While the mean number of wins is slightly higher, the overall range of the distribution is smaller

Question 7 (Table 3 and 4) assists in looking at the "oh-no" insight (moment). This is done with the assumption that all other moves constitute the knowledge point as referred to by Solomon and Perkins. These points or moments usually would signal when a change in the current course of action is required. These teams met in the first round. Learning is exhibited here in that the desire to consider taking moves back does not occur until later rounds.

Tables 5 and 6 show the responses of these two teams to the last question. We can also see evidence of learning in the reflective answers that are given. For example the responses by Marketing in Tournament 2, Round 3: "Yes, our strategy is developing more and more with every game. It is also evident in the consistency of thought in Round 7 of the first tournament and Round 6 of the second tournament.

TABLE 1
Connect 4 Tournament

Team	First Game Won	Lost	Tie	Place Finish
Finance	3	4	1	4
Human Resources	4	4		2
Operations	3	4	1	5
Accounting	4	4		3
Board of Directors	3	5		6
Executive Mgt.	6	2		1
Marketing	3	5		7
Mgt. Info. Sys.	0	7		9
Business Level	3	5		8

Second Game

Team	Won	Lost	Place Finish
Finance	4	4	4
Human Resources	3	5	6
Business Level	6	2	2
Executive Mgt.	2	6	9
Mgt. Info. Sys.	4	4	5
Board of Directors	3	5	7
Operations	3	5	8
Accounting	6	2	3
Marketing	7	1	1

TABLE 2
Distribution of Win-Losses
First Tournament

Number	1			5	2		1		
Wins	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Mean	3.2 wins
Mode	3 wins
Range	7

Distribution of Win-Losses
Second Tournament

Number			1	3	2		2	1	
Wins	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**

Mean	3.7 wins
Mode	3 wins
Range	6

TABLE 3
Question 7 - Tournament 1
Team: Human Resources

Question: At what point in the game, did you wish you could take a specific move back? If so, at what point in the game would you want to take it back?

Round	
1	No
2	
3	
4	Yes, at the very end
5	No
6	No
7	Yes, at the end when we could have went two ways to block them we picked the wrong spot.
8	We needed to take a few moves back in the middle

Question 7 - Tournament 2
Team: Human Resources

Round	
1	No
2	No, we were satisfied with all our moves because we had a strategy
3	Yes, at the very end
4	No
5	Yes, second to last move
6	No
7	No
8	No

TABLE 4
Question 7 - Tournament 1
Team: Marketing

Question: At what point in the game, did you wish you could take a specific move back? If so, at what point in the game would you want to take it back?

Round	
1	No
2	No
3	No
4	No
5	No
6	No
7	Yes, the beginning we should have been more vertical
8	

Question 7 - Tournament 2
Team: Marketing

Round	
1	No
2	No
3	No
4	No
5	No
6	Yes in the beginning
7	Yes 3rd checkers. It is vital to conquer the middle
8	No

TABLE 5
Question 9 - Tournament 1
Team: Marketing

Question 9: What did you learn?

Round		Team played
1	Different ways to set up a connect 4	Human Resources
2	I need to rethink my strategy and think ahead	Finance
3	A good balance of offense and defense is the key to success	Business Level
4	To plan moves in advance	Operations
5	We learned one must continue to try and keep attempting 3 in a row and it will eventually pay off	Accounting
6	Learned to start ahead	Board of Directors
7	Sometimes you need to slow down and pace yourself and look around	Exec. Mgt.
8		Mgt. Info. Sys.

Question 9 - Tournament 2
Team: Marketing

Question 9: What did you learn? Can you draw any comparisons to the first part of the tournament?

Round		
1	Yes, we're trying to use odds more.	Human Resources
2	Yes, more people have better strategies and have researched	Finance
3	Yes, our strategy is developing more and more with every game.	Business Level
4	We need to set up many moves so others need to block us. More people have strategies now and are harder to beat.	Operations
5	Distract the opponent	Accounting
6	To not be so impatient and really take your time	Board of Directors
7	Play the middle	Exec. Mgt.
8	Nope	Mgt. Info. Sys.

TABLE 6
Question 9 - Tournament 1

Team: Human Resources

Question: What did you learn?

Round		Opponent
1	We learned that the best way to win us to set yourself up with an opportunity to put your chip in to the left or right	Marketing
2		Exec. Mgt.
3		Mgt. Info. Sys.
4	We need to look forward	Board of Directors
5	We realized that playing passively was not going to win	Finance
6	eight eyes are better than 6	Business Level
7	To look at the long run opportunities instead of the short run	Operations
8	going second is just as bad as going first	Accounting

Question 9 - Tournament 2
Team: Human Resources

Question: What did you learn? Can you draw any comparisons to the first part of the tournament?

Round		Opponent
1	It's better going second	Marketing
2	Slow down and work towards the top. This is a new strategy we have developed since the start of the tournament	Exec. Mgt.
3	didn't play them	Mgt. Info. Sys.
4	Slow down and work towards the top. This is a new strategy we have developed since the start of the tournament	Board of Directors
5	to have a plan/strategy	Finance
6	We learned to take our time and visualize our moves and their moves	Business Level
7	plan for later moves and build toward the top	Operations

TABLE 7
Won-Loss Records for Both Tournaments

Team	Finance	Human Resources	Operations	Board of Directors
Finance		0-1	.5-1	1-1
Human Resources	1-0		1-0	0-1
Operations	.5-0	1-1		1-0
Board of Directors	0-0	1-0	0-1	
Accounting	1-0	1-1	1-1	0-1
Mgt. Info. Sys.	0-1	0-1	0-0	0-0
Executive Mgt.	1-1	1-0	1-0	1-1
Marketing	1-0	0-1	1-1	0-1
Business Level	0-1	0-0	1-1	0-1

	Accounting	Mgt. Info. Sys.	Exec. Mgt.	Marketing	Business Level
Finance	0-0	1-0	0-0	0-1	1-0
Human Resources	1-0	1-0	0-1	1-0	1-1
Operations	0-0	1-1	1-1	0-0	0-0
Board of Directors	1-0	1-1	0-0	0-1	1-0
Accounting		1-1	0-0	1-0	0-0
Mgt. Info. Sys.	0-0		0-0	0-0	0-0
Executive Mgt.	1-1	1-1		1-0	1-0
Marketing	0-1	1-1	0-1		1-1
Business Level	1-1	1-1	0-1	0-0	

Note; The first number is the record for the first meeting in the first meeting in the second tournament tournament and the second is for the second tournament. A 1 designate a win and a 0, a loss.

Table 7 shows the effect of positive knowledge transfer in the sense that some teams defeated their opponents in the second tournament when they lost in the first (Finance & Human Resources). Positive knowledge transfer can also be seen where one team beat a team both in the first tournament and also the second (Accounting & Human Resources). Negative knowledge transfer would then exist when a team was beaten twice by the same team in each of the two tournaments (Operations & Accounting), and where a team that won in the first round lost to that same team in the second (Human Resources and Operations).

CONCLUSION AND DISCUSSION

We have seen through earlier research that learning can take place when playing from round to round in a single game context. A truer measure of whether learning has truly occurred is to consider whether the transfer of that knowledge has occurred and being used in subsequent game situations. An indicator of this is in the won-loss records of the teams which participated. It was found that the distribution of wins is smaller in subsequent games and the average number of wins increased. This is a direct result of positive knowledge transfer between game situations where greater parity would tend to exist.

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