Fantasy Sports Games as Cultures for Informal Learning

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Impact

Informal learning generally refers to activities that occur outside of school settings and can be characterized by voluntary rather than mandatory participation (Crane, 1994). Numerous informal learning media exist, such as exhibits in museums and zoos, television and other broadcast media, books and other print media. In all cases, learners' decisions to explore these environments constitutes a form of free-choice learning (Falk & Dierking, 2002), where people control what they want to learn as well as where, when, and whom to learn with.

The majority of informal learning environments are designed by researchers and practitioners and offered to people as possible venues for free-choice learning. Our proposed research is somewhat different, as we will begin with an existing community of motivated individuals to understand a) if and what they are learning as members of the community, and b) how to design supports to increase the amount of informal learning that may exist. In a sense, we are trying to extend informal learning to "everyday" contexts, where opportunities for learning may exist as people engage in activities that would not be considered "pedagogical."

Numerous sociocultural studies have tried to characterize differences between the types of learning that occur in formal educational contexts and the world outside of schools. For instance, studies of activities such as carpet laying, farming, candy selling (Carraher, Carraher, & Schliemann, 1985; Saxe, 1991), shopping (Lave, 1988), and game playing (Nasir, 2002; Nasir, 2005) have examined the connections between mathematics learning and cultural practices associated with activity. The perspectives adopted in these studies focus on the cultural practices in which learning occurs. That is, the unit of analysis focuses on cultural norms as expressed through relationships with the environment, tools, and peers rather than isolating individual cognitive abilities. One important finding of such work is that mathematical learning occurs as people attempt to fulfill goals during everyday activity (e.g., saving money while still buying enough groceries to last for a week). The expression and use of mathematical knowledge in these settings rely on tools and artifacts situated in the environment, leading to norms, values, and conventions that generally look very different than those found in formal mathematics education.

Most sociocultural studies of everyday math have been conducted in physical locations (e.g., street corners, playgrounds, supermarkets), allowing researchers to visit places to observe and interact with participants. However, new forms of distributed and online communities and cultures have emerged as a result of the Internet and the World Wide Web. Many of these communities may exhibit ways of learning that resemble the everyday contexts studied by sociocultural researchers. But the types of tools and artifacts that participants interact with are likely different than those seen in physical communities, as many of them will be virtual, computational tools (e.g., search engines, message boards). More so, studying the practices occurring within online communities is complicated by the distribution of participants across time and space.

Our investigations focus on the cultural practices used by individuals and groups to facilitate informal learning in distributed, online communities. While numerous Web-based forums have been developed to facilitate formal and informal learning, we will examine the everyday forms of cognition and learning that take place online despite their lack of explicit, pedagogical structure. That is, we are interested in online communities that exist for purposes such as entertainment but have the potential to become informal learning environments because of their cognitive and sociocultural demands on participants. For instance, many online gaming sites provide hints and cheats for players, and the dialogues that lead to the sharing of information can be thought of as a sort of informal learning (Gee, 2003). Communities like Neopets (http://neopets.com) similarly engage millions of children in activities that resemble commerce and trade, possibly leading to informal learning of economics despite the fact that the environment was established for entertainment.

An important aspect of our research is the combined analysis of existing communities of practice to determine ways that they do (and do not) learn plus the design of supports for informal learning based on these analyses. Rather than designing a completely new intervention, we want to start with intrinsically motivating contexts, understand the forms of informal learning taking place, and then build supports to enhance learning opportunities. More so, our plan is to analyze existing communities and use our findings to learn how to create similar environments for adolescents and young adults that support the learning of formal mathematical skills through informal interactions.

Fantasy Sports

Our research targets the growing community of online, *fantasy sports* gaming. Recent estimates suggest that more than 15 million people regularly participate in these games (A.T. Kearney Inc., 2003; Ballard, 2004), where players assume the role of "league owners," selecting professional athletes to become part of their "ideal" sports teams.[1] The rules of the game vary across fantasy leagues, but all use the statistics generated by individual athletes to generate points for the fantasy teams. That is, real athletic performances generate data for fantasy teams. The player's goal is to choose from the available pool of professional athletes in their chosen sport that will provide the highest number of points for their fantasy team. Surveys of fantasy sports players suggest that they commit their time and energy to these games to make and maintain friendships, have fun, compete with others, and enhance their existing passions for sports. The games have elements of challenge, curiosity, and fantasy common to many games (Malone, 1981) along with collaboration and competition as players work with and against friends to select winning combinations of athletes.

Our interest in fantasy sports begins with the types of decisions that players make when selecting their ideal teams. For example, players of ESPN's Fast Break fantasy basketball game login to a Web site and select five NBA/WNBA[2] athletes and a coach for their teams. Each athlete/coach has a talent ranking, and the total rankings for each team cannot exceed a fixed ceiling (e.g., 100 points). Figure 1 shows a fantasy team with a talent value of 100 (rightmost column). This talent ceiling[3] constrains players' choices of athletes, typically limiting them to select one or two "superstars" and then requiring closer scrutiny of "role athletes" to complete their rosters.

TOTALS FOR Friday, Nov. 12

POS	PLAYER, TEAM	OPP	MIN	FG/A	FT/A	REB	AST	TO	STL	BLK	PTS	F Brk*	AVG**	VALUE
PG	**Steve Francis**, ORL	**LAL**	41	11/23	9/11	8	9	3	0	1	32	33	22.2	20.1
SG	**Emmanuel Ginobili**, SA	**MIA**	35	8/12	8/10	7	7	4	6	1	29	40	16.8	15.8
SF	**Rashard Lewis**, SEA	**TOR**	41	6/20	0/0	7	2	3	1	2	15	10	19.3	17.4
PF	**Tim Duncan**, SA	**MIA**	40	6/14	5/14	13	6	1	2	3	17	23	28.0	21.4
C	**Shaquille O'Neal**, MIA	**@SA**	40	9/21	5/7	21	4	3	0	2	23	33	24.0	20.5
Cch	**Boston Celtics**	**CHA**	Winning Pct: 1/1 = 1.000									5	2.4	4.8
											Totals	144	**112.7**	**100.0**

Figure 1: A fantasy team in ESPN's Fast Break basketball game.

Players accumulate points according to each selected athlete's performance. All fantasy games include a model that maps statistical records of an athlete's performance into a single point value. For instance, Equation 1 shows the formula used to assign points to athletes in ESPN's Fast Break game.

$$\text{Athlete Score} = (PTS + REB + AST + STL + BLK) - ((FGA - FGM) + (FTA - FTM) + TO)$$

where:

PTS = points scored, *REB* = total rebounds, *AST* = assists, *STL* = stolen balls,

BLK = blocked shots, *FGA* = field goals attempted, *FGM* = field goals made,

FTA = free throws attempted, *FTM* = free throws made, *TO* = turnovers

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Equation 1: ESPN's formula for calculating athlete points in their Fast Break fantasy basketball game.

If an athlete makes 5 out of 10 shots, 5 out of 7 free throw attempts and totals 15 points, 6 rebounds, 4 assists, 3 steals, 2 blocked shots, and 3 turnovers, the player would receive 20 points in the ESPN game:

$$(PTS + REB + AST + STL + BLK) - ((FGA - FGM) + (FTA - FTM) + TO)$$

$$(15 + 6 + 4 + 3 + 2) - ((10 - 5) + (7 - 5) + 3) = 20$$

[1] We will use the term "player" to refer to fantasy sports participants, "athlete" when referring to professional athletes chosen for fantasy teams.

[2] National Basketball Association/Women's National Basketball Association.

[3] Many fantasy games refer to this ceiling in terms of athlete salaries.

The player's goal is to choose athletes that maximize their total points while remaining under the talent/salary maximum. Without the constraint on talent/salary, players might choose the best athletes at every position and easily maximize their scores. But the talent ceiling forces players to compare athletes and decide which five out of the large athlete pool[4] have the best chances of amassing the most fantasy points.

In this sense, fantasy games can be thought of as resource allocation tasks, as players must choose athletes (resources) to maximize payoffs while working with limited salary and/or talent assets. Team selection involves numerous decisions that require different sorts of information seeking and statistical analyses. For instance, it is fairly simple to consult Web resources to determine if an athlete is injured, suspended, or otherwise not playing in real games: Athletes that are not playing cannot generate points, and we suspect that the best fantasy players regularly use published information to track injuries, suspensions, and so on.

More complex decision-making occurs when players have to choose between athletes while working within talent/salary constraints. For example, players may have to consider multiple variables (e.g., average points scored, talent rankings, rank changes) when assembling their teams. The best players might use a number of strategies and resources to select athletes for their teams:

1) Information from media sources such as the ESPN and Sports Illustrated Web sites (e.g., avoiding athletes that are injured and/or suspended)
2) Information from dedicated fantasy statistics and information sites (e.g., www.hoopsklyce.com, www.stats.com) that provide players with hints and strategies for team selection
3) Statistical data from past performances that can suggest costs and benefits of certain selections (e.g., athlete *X* may have a poor scoring record when defended by athlete *Y*)
4) Reflecting on failures and successes of prior decisions made during team selection (e.g., recognizing that previously unselected athlete *X* has become a strong choice for one's team)

Our first research question concerns the decisions made within the culture of fantasy sports, as players may be engaging in a great deal of thinking and learning around mathematical concepts such as optimization and statistical analyses. Some of these decisions may be mathematical while others may be tied to personal preferences, beliefs, and biases. We will focus our studies on three aspects of fantasy sports practice that may influence the use of informal mathematics (Saxe, 1991): 1) the structure of decision-making activities, 2) artifacts and conventions that enable the activities, and 3) social interactions between game players. The intent is to characterize the relationship between player's goals and their use of mathematical knowledge in fantasy sports games.

The second aspect of the research focuses on transforming play into informal learning activities. If fantasy team selection is driven by informal mathematical knowledge, can we use these gaming contexts to help players reflect on their existing decision strategies and incorporate more sophisticated, formal analyses into their practices? Players currently work within computational environments to make their decisions: We will use what we learn from initial studies of fantasy sports play to complement existing tools with additional *scaffolds* for reflection and data analysis. Scaffolding refers to supports that help learners perform tasks that are outside their independent reach while simultaneously developing skills necessary for independent performance (Rogoff, 1990; Wertsch, 1979; Wood, Bruner, & Ross, 1976). The scaffolding metaphor has been used to describe ways that computer-based learning environments can support learners in extending their performance and proficiency in disciplinary practices (Guzdial, 1995; Quintana et al., 2004; Reiser, 2004; Sherin, Reiser, & Edelson, 2004).

Existing fantasy games often provide statistical data about players, but they do not include tools and artifacts that could assist players in analyzing and making sense of these data. Our research will integrate 1) metacognitive scaffolds into existing games to help players examine the reasoning and logic underlying their decisions, and 2) procedural scaffolds to reduce cognitive load for repetitive tasks. Metacognitive scaffolds will include prompts that focus players on important aspects of decision-making and process models (Lin, Hmelo, Kinzer, & Secules, 1999) that illustrate how experts might approach a specific decision. Our goal is to extend fantasy games with scaffolds that help players gain deeper insights into decision heuristics and mathematical concepts associated with evaluating, making decisions, and arguing with statistical data.

[4] There were 156 WNBA athletes and 475 NBA athletes in 2003-2004.

Audience

We are interested in all fantasy sports, but our initial research focuses on fantasy basketball games. The performance of basketball teams and athletes can be quantified as statistical data and understood using various mathematical techniques (e.g., Hollinger, 2003; Oliver, 2003), thus being an ideal domain for the informal mathematics that we want to identify and enhance. Basketball has also been demonstrated to be a sport in which young people apply statistical strategies. For instance, Nasir (2000; 2002) studied middle school and high school African American male basketball players to understand how they used statistics to evaluate their performances. She found that these players often used quantitative evaluations to compare their own play to their peers and between professional/college athletes. High school players used statistics in similar ways but also used them to compare themselves against statistical norms for the position they played; they made use of proportional relations (e.g., averages and percentages) to establish baselines for their own playing abilities.

Studies of achievement among different racial groups have indicated that African American and Latino students score lower on traditional tests (Johnson, 1984; Reyes & Stanic, 1988) and are less likely to enroll in advanced mathematics courses than Caucasian and Asian students (Campbell, 1986; Secada, 1992). However, Nasir (2000) reported that high school basketball players who were unable to solve statistical problems worded in the "grammar of schools" could generate solutions when the same problems were phrased in terms of basketball. This suggests that basketball can be a powerful context for framing statistical understanding and may appeal to learners who would otherwise avoid mathematics in formal settings.

Our research will target high school and undergraduate players (ages 14-21) since these learners may have developed oppositional frames where they purposely reject mainstream instructional goals and values (Fordham & Ogbu, 1986; Ogbu, 1987). The motivational aspects of fantasy sports games may inspire these youth to engage in mathematical activities typically shunned in formal education. The test sites for our design research are urban, after-school and technology centers with large minority populations that will allow us to examine oppositional issues around the mathematics of fantasy sports. This study's focus on basketball as a context for informal learning may contribute to our understandings of student learning, particularly minorities, as well as providing a setting where mathematics can be explored though familiar cultural practices.

Basketball is also a focal point for recreation and identity for many African American youth (Mahiri, 1991; Nasir, 2000). Studies by the Amateur Athletic Foundation and ESPN (SRI, 2001) suggest that 82% of 8-17 year olds watch sports on television with 71% of those watching televised NBA games. 94% of NBA viewers are African Americans vs. 65% of Caucasians. This appears to carry over to fantasy basketball where 46.2% of non-Caucasians play the game vs. 22.4% of Caucasian players (Deeney, 2004). We will design our software to accommodate multiple sports, but prior research suggests the preferred status of basketball in minority communities, hence we will use it as the initial domain for our inquiry and designs.

The use of sports may appear to be biased towards male participants, but there is evidence to suggest that females will not be excluded from our research efforts. Recent demographics suggest that 7-25% of fantasy sports players, i.e., 1-4 million people, are adult women (Deeney, 2004; FSTA, 2003). Little is known about younger players, but children's participation in fantasy sports may be similar to the use of other sports-related media. For instance, 71% of 8-17 year olds reported that they play sports-related videogames, and 37% of those played basketball games. While some sports exhibit notable variations between genders, basketball videogames are played by similar percentages of boys and girls (39% vs. 35%, SRI, 2001), and we imagine analogous participation in our fantasy basketball games. However, girls are more inclined to follow women's basketball on television than boys (37% vs. 23%, SRI, 2001), so we will implement two games, men and women's professional basketball, and allow participants to choose their preferred sport. The first two years of research will also investigate previously reported gender differences associated with computing (e.g., Cassell & Jenkins, 1998; Honey et al., 1991; Marra & Pinkard, 2000; Turkle, 1988) through participatory design with our participants.

Intended Impact

The intended impact of our work is to develop learners' abilities to 1) use and manipulate statistical data to make informed decisions in fantasy sports and, 2) reflect on and explain the reasoning underlying their decision-making strategies. We want to enhance learning experiences for current players by integrating scaffolds into existing fantasy sports games, but we also want to learn more about strategies used during team selection in order to develop new informal learning environments for middle school to college-age youth. At the broadest level, the goal of our project is to enhance players' abilities to become more mindful and reflective about their decision-making and use of everyday mathematics.

The formative and summative evaluations of the work will be theory-driven, with an emphasis on an inductive approach (Chen, 1990; Chen & Rossi, 1980). This approach will allow the evaluators and the project team to learn from the experiences, perspectives, and actions of project participants, generating a portrait of the actual nature of adolescents' engagement with the prototype fantasy sports environment that can be contrasted with the theoretical framework from which the project has been developed (Chelimsky & Shadish, 1997). This approach will allow us to investigate the "fit" between the implemented designs and the project's guiding frameworks (formative evaluation) and to examine the impact of the program on adolescents' use of everyday mathematical reasoning and problem-solving strategies more generally (summative evaluation).

In the first year of the project, the main goal is to gather data to inform the design of supports in the fantasy game environment. We will survey a random sample of existing game players and conduct naturalistic observations of the online communities to identify strategic and cultural norms related to decision-making. We also intend to interview expert players to enhance our understanding of specialized skills and strategies of decision-making that develop over time.

The second year of research will include rapid design prototyping and participatory design methods to inform the design and development of our fantasy gaming/learning environment. Data collection will include one-to-one and small group evaluations (Smith & Ragan, 1993) of the gaming environment at the test sites.

In the summative evaluation (Year 3), we will investigate if adolescents engaging in sustained use of the prototype games demonstrate growth over time in their use of specific forms of mathematical reasoning and decision-making. We will also look for evidence of increased awareness and understanding of their use of mathematical reasoning and problem-solving strategies outside of the gaming environment. The hypothesis is that engaging in fantasy sports play can provide opportunities to practice the use of mathematical reasoning skills and also increase players' abilities to explain their mathematical thinking strategies to others, abilities that may transfer beyond fantasy sports.

Research findings will be disseminated through presentations and peer-reviewed publications to formal and informal learning communities (e.g., American Association of Museums, American Educational Research Association, Association of Science-Technology Centers, International Society of the Learning Sciences). We will also present the research findings to industry leaders at annual meetings of the Fantasy Sports Trade Association to advocate the use of fantasy sports for informal learning. Reports will also be submitted to informalscience.org, a Web site maintained by the University of Pittsburgh to share knowledge about informal learning standards and practices. We will document incremental findings in research Weblogs (Blogs) to encourage frequent updates and peer critique from others in the informal learning community.

This study will test the hypothesis that engaging in fantasy sports play provides not only opportunities to practice the use of mathematical reasoning skills, but to articulate them to others and demonstrate their use, consequently increasing their ability to explain their mathematical thinking strategies to others, an ability that may transfer beyond the gaming environment. Research on mathematics learning suggests that this ability is important to mathematical learning in general and is a key to a learners' ability to recognize how various thinking strategies can be used across multiple settings (NCTM, 2000).

Collaboration

Senior Personnel

Priya Sharma is an assistant professor of Education at Penn State. Her research focuses on the design of scaffolds to facilitate critical and reflective thinking and the role of technologies in supporting practices of self-organized learning. Previous research focused on the facilitation of critical thinking in online environments (Sharma & Hannafin, 2004), while her current research examines the use and implementation of personal Web publishing technologies and practices in supporting reflective thinking and self-organized learning (Sharma & Fiedler, 2004).

Brian K Smith is an associate professor of Information Sciences & Technology and Education at Penn State. He has developed and studied a number of computational environments for informal learning, many of which focus on the use of "imagery as data," a methodology where learners observe, manipulate, and explain digital photographs and video to understand complex behaviors (Smith & Blankinship, 2000). The projects have been deployed in high school classrooms (Smith & Reiser, in press), zoos (CZS & LeTUS, 2000), after-school and senior citizen's centers (Smith, Blankinship, Ashford III, Baker, & Hirzel, 1999), science fiction conventions (Blankinship, Smith, Bender, & Holtzman, 2004), and medical settings (Frost & Smith, 2003).

Katherine McMillan Culp is the assistant director for research at the Education Development Center/Center for Children & Technology and the evaluation coordinator for the research. She has twelve years of experience in managing evaluations of innovative programs to improve the quality of technology use in K-12 classrooms and informal educational settings. For the past four years she has overseen evaluations of several of the Intel Corporation's Innovations in Education initiatives, including the Intel Computer Clubhouse Network. She has also conducted a series of program evaluations studying strategies for using modeling and simulation tools in science classrooms, as well as qualitative studies of technology integration at both the classroom and district level and a study of adolescents' engagement with virtual gaming environments.

Advisory Committee Members

Dr. Paula Hooper (TERC): Dr. Hooper studies issues of cultural identity and its impact on mathematical learning. Her doctoral work involved a longitudinal study of computer programming, focusing on the ways that young girls express themselves with computation. Dr. Hooper will assist us in studying fantasy sports communities from sociocultural perspectives as well as being a content advisor in the area of mathematics education and gender/cultural differences in technology adoption and use.

Mr. David Kleeman (American Center for Children and Media): As the Executive Director of the American Center for Children and Media, Mr. Kleeman has pioneered efforts to improve the quality of children's television programming and other media. His expertise with informal learning audiences and educational media will be invaluable as we study and design environments for fantasy sports players.

Dr. John Maeda (MIT Media Laboratory): Dr. Maeda is a leader in computational aesthetics and design. His *Design by Numbers* text and computer programming environment have been adopted by a number of design schools to train artists in the fundamentals of computation (Maeda, 2001), and he has recently developed online environments to train children and adults in graphic design. We will consult with Maeda on issues of visual design and information visualization.

Dr. Nichole Pinkard (University of Chicago/Inquirium LLC): Dr. Pinkard has developed theoretical frameworks for the design of culturally relevant human-computer interfaces. She also works with *Inquirium*, a company that develops computer-based learning environments for museums and schools. Dr. Pinkard will provide expertise in designing robust learning environments for young girls and minorities in urban settings.

Dr. Mitchel Resnick (MIT Media Laboratory): Dr. Resnick co-founded the Computer Clubhouse Network of after-school centers that serve underserved youth in the US and abroad (with support from Intel Corporation) as well as co-developing *The Virtual Fishtank*, an exhibit at Boston's Computer Museum that helps children understand the workings of complex systems. Dr. Resnick will allow us to deploy and evaluate our designs to his Computer Clubhouses in Boston and other cities and provide expertise on designing, deploying, and evaluating computer-based learning environments in informal settings.

Organizational Partners

The Fantasy Sports Trade Association (FSTA) is a non-profit group founded to encourage participation in fantasy sports leagues and protect commercial and consumer rights of players and business owners. FSTA members include some of the biggest corporations in fantasy sports, including CBS Sportsline, ESPN, Fox Sports, and Yahoo. FSTA Chairman Rick Wolf has helped forge connections between the researchers and fantasy sports companies, allowing us to better understand the realities of the industry and its audience.

Our second partner, the Magic Johnson Foundation (MJF), is committed to the development of programs that serve health, educational, and social needs in inner-city communities. One of their numerous contributions has been the establishment of 15 technology centers in seven urban markets, including Philadelphia, PA and Harlem, NY. Kawanna Brown, President of MJF, will be our primary contact, allowing us to deploy our designs in their technology centers during year three.

External Evaluation

The formative and summative evaluation of this project will be conducted by the Center for Children and Technology/Education Development Center, Inc. The evaluators will collaborate closely with the primary research team throughout the life of the project. In Year 1, the evaluators will participate in preliminary investigations into the culture of fantasy sports play. While the research team will have responsibility for data collection, the evaluators will review collected data and participate in data interpretation and articulating key findings that will inform development efforts during Year 2.

As the researchers develop and test the prototype fantasy sports environment in Year 2, the evaluators will use multiple methods to capture and analyze adolescents' initial engagement around the designs as well as their use of the environment over time. Primary modes of data collection will be direct observation, interviews, and tracking of online activity. In Year 3, the evaluation team will continue to provide formative feedback and conduct summative evaluations to test the efficacy of the design prototypes as a support to adolescents' development of everyday mathematical thinking.

Innovation

The main deliverable will be an online fantasy sports environment with embedded scaffolds and tools for supporting mathematical reasoning and decision-making. This environment will include a suite of resources including communication spaces and data analysis/visualization tools. The software will be freely available to research participants, and we will not provide extrinsic rewards (e.g., prizes or money) that could be associated with gambling. The iterative design and refinement of this environment is guided by two secondary deliverables—a descriptive report of informal practices of math learning and decision making drawn from existing, authentic environments and the design and development of specific representational tools for scaffolding mathematical reasoning and decision making.

Research Questions

The proposed research will span three years. In Year 1, we will focus on understanding the everyday reasoning practices used by fantasy sports players: The strategies used to make decisions, the role of artifacts and tools (computational and non-computational) in forming decisions, and the nature of social interactions between game players. Year 2 focuses on the design of scaffolds to assist players in posing questions, analyzing data, and making decisions with data. In Year 3, we will evaluate the design work by deploying two games, men and women's basketball, on the Web. Several physical locations will be targeted to recruit players, including schools in State College, PA and technology centers in Boston, New York, and Philadelphia. The research will characterize existing practices in fantasy sports communities, formalize these as scaffolds in designed environments, and evaluate the designs to see if they make an impact on decision-making and the use of mathematical knowledge. Three research questions will be investigated during Year 1 and revisited in Year 3:

1) What decision strategies and informal mathematical practices do fantasy sports players use during game play?

"Normative" models of decision making suggest that people systematically search for all information related to a decision without bias and carefully weigh the utility of each alternative before committing to a course of action (Beyth-Marom, Fischhoff, Quadrel, & Furby, 1991; Pliske, McCloskey, & Klein, 2001). Decision researchers later demonstrated that humans often fail to use follow normative strategies (e.g., Kahneman, Slovic, & Tversky, 1982; Kahneman & Tversky, 2000) and began identifying heuristics that could lead to biases in choice behavior. Researchers examining decision making in everyday contexts vs. laboratory settings have further questioned normative models (Gigerenzer, Todd, & The ABC Research Group, 1999; Klein, 1999; Mehan, 1984; Salas & Klein, 2001; Zsambok & Klein, 1997), claiming that cognitive heuristics can lead to robust and accurate inferences in certain domains. These researchers suggest the use of domain-specific case studies to identify the types of heuristics that guide different forms of everyday decision making. We are not aware of attempts to understand how decisions are made in fantasy sports games, so our first year of research will involve observing players to understand the extent that they use normative and heuristic strategies for decision-making.

We will develop methods to distinguish novice and expert players similar to those used in studies of racetrack handicappers (Ceci & Liker, 1986a; Ceci & Liker, 1986b). We are currently inviting players of ESPN's fantasy games[5] who ranked in the top 5% to participate in online surveys designed to identify strategies used in team selection. These participants will also be asked to participate in interviews by email and phone to further our understandings of their strategies through more open-ended questioning.

We will also observe existing fantasy sports leagues to understand how expert and novice individuals choose their teams, if and how players use statistical analyses to inform their decision-making. These studies will use a fantasy sports engine that we have built at Penn State. We will recruit adolescents and adults that regularly engage in fantasy sports from State College High School and Penn State to play our game, allowing us to overcome issues associated with distributed communities (as all participants will be in the State College, PA area) and observe participants as they make their decisions. Surveys and structured interviews will be used to assess strategies used during fantasy sports play.

One aspect of expertise in fantasy sports is related to knowledge: Expert players may have extensive knowledge of the game that is stored, organized, and retrieved more efficiently than novices (similar to studies of expert chess players, e.g., Chase & Simon, 1973; De Groot, 1978). For instance, expert fantasy players may have better memories for statistical data, athletes who consistently perform well, etc. They may also have better understandings of all athletes as opposed to novices who may select their athletes based on "recognition heuristics" (Goldstein & Gigerenzer, 1999), i.e., choosing athletes on the basis of their popularity rather than making decisions based on statistical data.

A second characterization of expertise emphasizes cognitive processes—how people plan and reason as they assemble their teams. Domain experts often spend more time on strategic planning than their novice counterparts (Sternberg et al., 2000). In fantasy sports play, experts may possess planning and analysis skills that allow them to make informed predictions from statistical evidence. Novices may lack procedural knowledge required to conduct deep investigations of statistical data that could inform their decisions. Experts, on the other hand, may have analytical skills that facilitate close scrutiny of sports statistics—asking questions of available data, developing their own spreadsheets and analysis tools to inform athlete selection, etc.

However, experts may also possess misconceptions about the nature of sports statistics that can result in poor decision-making. For instance, Gilovich, Vallone, and Tversky (1985) discovered that many basketball fans believe that athletes have a better chance of making a shot after having made the last two or three shots. This idea of a player going on a "streak" or having a "hot hand" has been challenged by researchers who have shown that the proportion of shots hit by an athlete are independent events, unrelated to how many previous shots in a row were hit or missed (Gilovich et al., 1985; Vergin, 2000). Regardless of the statistical evidence, fantasy players are likely to believe in the "hot hand," possibly because streaks are memorable occurrences (Gilovich et al., 1985), and/or that players believe that small sample sizes can be used to generalize the probability of an event occurring (Tversky & Kahneman, 1974). The hot hand belief has also been explained as a "cognitive illusion," an example of people generating explanations to account for perceived patterns due to their inabilities to accept randomness (Falk & Konold, 1997).

There may be good reasons to adopt the "hot hand" belief in fantasy sports if it represents an instance of bounded rationality (Gigerenzer & Todd, 1999). In other words, fantasy players may use adaptive strategies that are "good enough" to achieve their goals rather than employing normative models. We will attempt to create a taxonomy of players' decision strategies, classifying them into categories of normative and heuristic decision-making. Classifying these decisions and connecting them to successes and failures will help us understand the utility of various strategies in maximizing points during fantasy team selection.

2) How are decision-making strategies influenced by the player interactions with artifacts?

Fantasy sports decisions are likely to be influenced by the Web-based tools used to select athletes, compete with other players, and so on. Indeed, a fundamental assumption of our work is that we can enhance informal learning by designing scaffolds that make mathematical formalisms and practices explicit in fantasy sports interfaces.

In Year 1, we will study tools and artifacts used by fantasy sports players to understand their influence on decision-making. Our focus will be on external resources used by players during roster selection (e.g., sports Web sites, fantasy sports Web pages and magazines) to see their effects on game play. The purpose is to understand how the pres-

[5] Approximately 216,000 and 21,000 people played the NBA and WNBA games in 2003-2004.

ence (or lack) of these artifacts and their presentation of statistical and non-statistical information facilitate sense making during fantasy sports play.

The visual representation of information can influence reasoning and understanding in various domains (Suthers & Hundhausen, 2003; Wojahn, Neuwirth, & Bullock, 1998). For instance, many people have difficulties interpreting statistical covariation from contingency tables and/or scatterplots despite intuitive understandings about relationships between phenomena (Konold, 2002; Konold & Higgins, 2002). Noss, Pozzi, and Hoyles (1999) studied the statistical reasoning of nurses who understood from experience that blood pressure tends to rise with age, yet they were unable to detect this relationship when viewing scatterplot data. A second representation that organized the data into "slices" by age (Cobb, McClain, & Gravemeijer, 2003; Noss et al., 1999) allowed the nurses to see the expected trends of higher blood pressure as people grow older. In short, the ways that data are visualized can have an impact on understanding and reasoning.

The design work in Year 2 will further scrutinize the representation of information used by fantasy gamers to create alternatives that may make mathematical concepts more explicit. For instance, current fantasy sports games often hide their underlying models for computing points. We envision systems that assist decision making by making these point formulas obvious to players. These designs will be prototyped and tested with learners at our test sites during the second year of research.

In Year 3, we will investigate whether adolescents without an extensive background in fantasy sports find the prototype gaming environment to be comprehensible and engaging, and if their engagement with it leads them to practice the targeted forms of mathematical reasoning and problem solving. Specifically, we will gather data to assess participants' understanding and reasoning behind the use of specific tools and artifacts. While scaffolding tools have the ability to support mathematical learning (e.g., Kao & Lehman, 1997; Linn, 1995), students' unanticipated use or misunderstanding of their purposes can impede learning (Oliver & Hannafin, 2000).

Our assessment focuses both on use and understanding and we will collect two types of data: Records of participant use of tools within an authentic context and reflective explanations of use. The online gaming environment will provide usage data, while targeted participant interviews and surveys will provide additional data on participant reasoning, views, and justification of tool use. This data will form the basis for comparative evaluation of intended and appropriate uses of scaffolding tools as compared to actual usage by participants. Additionally, we can derive benchmarks to compare players' strategies with those of expert players, focusing on mathematical reasoning and problem-solving strategies used to guide decision making. Measuring participants' abilities to reflect on their decision-making requires artifacts of thinking and behavior over a period of time. Data collected from online discussion boards will provide observational evidence of participant thinking and reflection. In addition, detailed content analysis will provide more empirical evidence of reflection and learning (Cecez-Kekmanovic & Webb, 2000). To the extent the environment does not accomplish these goals, the evaluations will seek to determine ineffective features and needs of the target population that remain unaddressed by our designs.

3) ***What online social and cultural interactions and practices support the decision making process for individuals and groups?***

Fantasy sports games are generally tied to community message boards where players discuss athletes, their fantasy teams, and other sports issues. These message boards may be interesting objects for study, as the discourse provides insights into players' thinking, argumentation, and explanations of athletic performances. For instance, we have found instances of players using statistical data to reflect on prior decision-making in online message boards (Figure 2).

We will try to identify the support mechanisms that are generated and perpetuated within the community by analyzing discussion boards and other online interactions. We will examine interactions at two levels to derive an inclusive understanding of the types of possible interactions. At the broadest level, we will examine a subset of the discussions and interactions for the entire community, which consists of individual players and members of various teams. At this level, all players are competing with each other. At the more private level, we will examine discussions and interactions within smaller, exclusive groups of players. Members of these groups are likely to have existing social relationships, so the interactions may be more specific than those taking place within the overall community.

Our initial approach to identifying interactions and practices will be to sample discussions within two levels of the discussion boards over a period of a month. For each sample, we foresee capturing discussions over the period of a day. The discussion board data gathered will be analyzed using a framework of computer based communicative learning (CMCL, Cecez-Kecmanovic & Webb, 2000) which provides for analyses of communication based on linguistic and social interactions.

Ohlde a Center??

Original Message (Posted: Jul 31, 2004 09:24 AM) Posted by: packers576542

Could have fooled me? 0 boards, 0-4 shooting??? Better look else where.. High School numbers..

Re: Ohlde a Center??

Posted: Jul 31, 2004 07:19 PM by: Luisa1028

she had an off night and vanessa hayden is now in the game. but ohlde is averaging 11 PPG with 43.7% shooting and 6 RPG in 24 games (30 min avg) - not too shabby for a rookie. if they'll be sharing center duties, they won't really be putting up a lot of numbers. so, for now - i'm staying away from picking either one of them.

Re: Ohlde a Center??

Posted: Jul 31, 2004 08:45 PM by: packers576542

Same here. Should have went with RR. had my finger on the button..?? Cost me 23 pts..

Figure 2: A conversation thread involving quantitative discourse and reflection around athletic performances.

Our initial approach to identifying interactions and practices will be to sample discussions within two levels of the discussion boards over a period of a month. For each sample, we foresee capturing discussions over the period of a day. The discussion board data gathered will be analyzed using a framework of computer based communicative learning (CMCL, Cecez-Kecmanovic & Webb, 2000) which provides for analyses of communication based on linguistic and social interactions.

We would like to examine and identify the common pool of resources and information used by community members to make decisions. Additionally, we want to examine the differences between expert (in this case, experts are players who win frequently or players distinguished by the frequency and adequacy of recommendations) and novice players' use of resources and their analyses. We would also like to examine whether expert players provide informal support to novice players and the specific instantiation of the support.

Methods and data analysis

In the first year of research, we will investigate the preceding three research questions with respect to existing fantasy sports settings, focusing on ESPN's Fast Break basketball game but also studying players across other fantasy sports to understand how they select their teams. These findings will feed design work in year two, and in year three we will revisit the questions, this time examining the effects of our designed interventions. Year one can be thought of as a baseline study that leads to design experiments; those will be tested with similar data collection and analyses in year three by the PIs and the external evaluators at the Center for Children and Technology.

Year 1: Design exploration and data collection in existing fantasy sports settings. The design team will use surveys, guided interviews, and observations of online gaming environments to identify expert players' strategic decision making and to understand the informal culture and practices that emerge in online sports leagues.

Surveys. The design team intends to survey the top 5% (approximately 1000 people) of winners on the ESPN game site and get their perspectives on their use of strategies in game playing. Participants will be contacted via email and provided a link to a web-based survey that asks questions related to their decision making strategies such as: what resources they use, what strategies do they employ consistently, how much time do they spend on different aspects of the game playing, whether they use any statistical data, etc. Additionally, respondents will be asked if they would be willing to participate in follow up interviews for more specific questioning.

Interviews. Selected participants will be interviewed via phone. A semi-structured interview guide will be used to probe for additional details on participants' individual and cultural practices as well as their usage of tools and resources to inform decision-making. Through our collaboration with FSTA, we will identify members of companies that run different fantasy games environments and interview them to gather their perceptions on players' successful and unsuccessful strategies. Given their experience with running online game environments, it is likely that these industry members would have developed a relatively robust understanding of the types of procedures that are most likely to prove successful within their specific environments.

Observations. While interviews will provide information on the practices of individual expert players, the observations will focus on building a more comprehensive picture of interactions between players and the environment. We will observe two online sports leagues—ESPN's NBA and WNBA games—and focus on the interactions between players to identify specific types of cultural practices and supports that evolve within the group. We will also request permission to observe discussions within competitive groups, which comprise a set of people who cooperatively make decisions about game playing. Thus, we will be able to examine interactions and supportive practices within a large competitive group as well as within smaller cooperative groups.

<u>Year 2: Design research</u>. The evaluation team will use observations, guided interviews, and reviews of online activity to capture broad and deep understandings of adolescents' reception and interpretation of the prototype game. Data analysis will focus on uncovering both the successful and problematic features of prototype tools and artifacts and on identifying unanticipated needs, perceptions, or practices among the target audience.

Observations. Evaluators will conduct extended observations of adolescents' use of design prototypes of the gaming environment in after-school program settings at least twice during Year 2. Observations will focus on understanding how face-to-face and online interactions around the environment influences game play and decision-making and capturing evidence of the think-aloud strategies adolescents use to guide their play.

Interviews. Evaluators will conduct a combination of face-to-face and online interviews with participants. Some interviews will be conducted during site visits for observations and will focus on gathering adolescents' reflections on their experiences using the fantasy games and their understanding of their own decision-making processes. Evaluators will also conduct repeated, periodic interviews with a subset of informants who will be selected from those adolescents who make frequent or extensive use of the gaming environment. Evaluators will speak with these adolescents approximately once every two months to track their changing responses to the site as it is developed and refined and to gather evidence of their reasoning and decision-making strategies over time. These interview data will be a key opportunity to investigate whether participating adolescents are building competence in their use of the targeted cognitive strategies over time.

Tracking online activity. The evaluators will work with the research team to ensure that all online discussion is archived and available for analysis. Evaluators will develop a coding scheme grounded in the findings from the Year One research regarding the specific reasoning and decision-making strategies the environment is designed to support and will use this scheme to code time-sampled portions of the archived discussion. This data will provide a broad look over time at how a range of participants are making use of the environment, and will allow for a limited amount of comparison of strategies used by different types of players (by, for example, sex or age, if this information can be associated with the available traces of online activity).

<u>Year 3: Continued formative evaluation and summative evaluation</u>. In year 3, the evaluation team will continue to conduct formative evaluation of the gaming environment as described in year 2 and conduct two small-scale studies in one of the sites participating in the research project.

Development of targeted skills. The first study will draw on the archive of online discussions and transcripts of interviews with the "informant" participants described above. This study will examine whether those youth who have made regular or extensive use of the gaming environment are showing evidence of growth in their use of the targeted forms of mathematical reasoning and decision-making strategies the environment is designed to cultivate.

Impact on awareness of strategies used. The second study will use highly structured clinical interviews to administer a near-transfer mathematical reasoning task to a random sample of adolescents in one of the participating sites. The study will use quasi-experimental methods involving youth who have played the game (we will define a minimum level of use for this group) and those who have not. Depending on the sample size available for participation, the study may or may not achieve a rigorous level of statistical reliability. This task will generate evidence not of adolescents' mastery of the targeted mathematical reasoning skills but of their abilities to identify the strategies they are using and to reflect on them. This study will test the hypothesis that engaging in fantasy sports play provides not only opportunities to practice the use of mathematical reasoning skills, but to articulate them to others and demonstrate their use, consequently increasing their ability to explain their mathematical thinking strategies to others, an ability that may transfer beyond the gaming environment. Research on mathematics learning suggests that this ability is important to mathematical learning in general and is a key to a learners' ability to recognize how various thinking strategies can be used across multiple settings (NCTM, 2000).

Web Deliverables

Online fantasy sports games allow players to choose athletes for their teams, see the results of their choices, and compare their performances against those of other players. If players want to perform more sophisticated analyses during their team selection, they have to leave the game environment and seek knowledge/tools elsewhere on the Web or through other media (e.g., spreadsheets, fantasy sports print publications). The goal for our software designs is create an integrated environment that augments fantasy play with tools to enhance decision-making.

The second year of research involves the development of scaffolds to augment existing fantasy sports games like the one we have created for our initial studies[6]. We can only imagine what these scaffolds might look like, as their designs will be based on lessons learned in the first year of studying existing decision-making practices. However, Smith and his students have spent two years playing various fantasy games to gain insights into the types of support learners might need to enhance their use of mathematics to inform decision-making. Their initial design thoughts appear below: These will become more focused in the first two years of research.

Supporting Analysis of Trends

Players of our game will have access to six years of NBA data stored on our server. These data describe the performances of all NBA athletes for the 82 regular season games plus those occurring during the two months of NBA playoffs. The result is a large repository of historical data that can be consulted to look for trends over time. For example, a player may want to examine the data when choosing between two athletes that have to defend one another during a particular game. Performing historical analyses in current fantasy games would be time consuming, if not impossible, since the data are not readily available; our system will make the data accessible and provide tools to facilitate comparison and analysis.

Supporting Reflection

When fantasy sports players can make decisions everyday, they may not stop to think about long-term effects of their decision-making. Most games keep a record of team changes made throughout the season, but we will augment these trails with prompts that ask players to explain how and why they made their choices. Requesting players to justify every decision would diminish the quality of game play, so our system will only present these prompts every 4-5 days. Those prompts will be accompanied by visualizations of previous decisions and justifications. In the best case, our system could analyze prior decisions and provide structured questions for players to consider. For instance, a player who always chooses Shaquille O'Neal might be prompted to seek alternatives through graphs comparing his performance to those of other athletes.

Supporting Reasoning With Formal Models

The formulas governing fantasy games (e.g., Equation 1) are typically invisible during the course of game play. We will make these models explicit in our interfaces and provide ways for players to understand the contribution of each variable to their overall scores. For instance, Figure 3 shows a dialog that could appear if a player chose to compare three athletes. We purposely split the equation into two parts to make it clear that offensive scores are subtracted from defensive points. In this case, Alana Beard has a lower offensive score than the other two athletes, so she may be the best choice if the player is trying to maximize points while minimizing talent ratings.

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[6] Our game is programmed in PHP and uses mySQL and Apache for database and Web services.

Figure 3: A design sketch that isolates defensive and offensive contributions to scoring in the fantasy game. Alana Beard gives up fewer offensive points than the other two athletes, making her a good choice for players trying to maximize points while minimizing talent ratings.

Supporting Argumentation

In our observations of fantasy sports message boards, we noticed arguments about athletes that were supported with statistical data. Players occasionally challenge others to provide them with evidence for an athlete's performance, and this evidence often came in the form of statistical data.

We will create a hybrid communications/data analysis space that allows participants to argue around athlete statistics. We envision something like Figure 4, where the left side shows an argument about an athlete's performance; the right side is a space that would allow players to "drag" images of athletes into a shared analysis space to compare their performances against various efficiency measures. The key innovation here is to combine traditional message boards with numerical analysis tools, hopefully to increase collaborative sense making around mathematical evidence as discussions and arguments unfold.

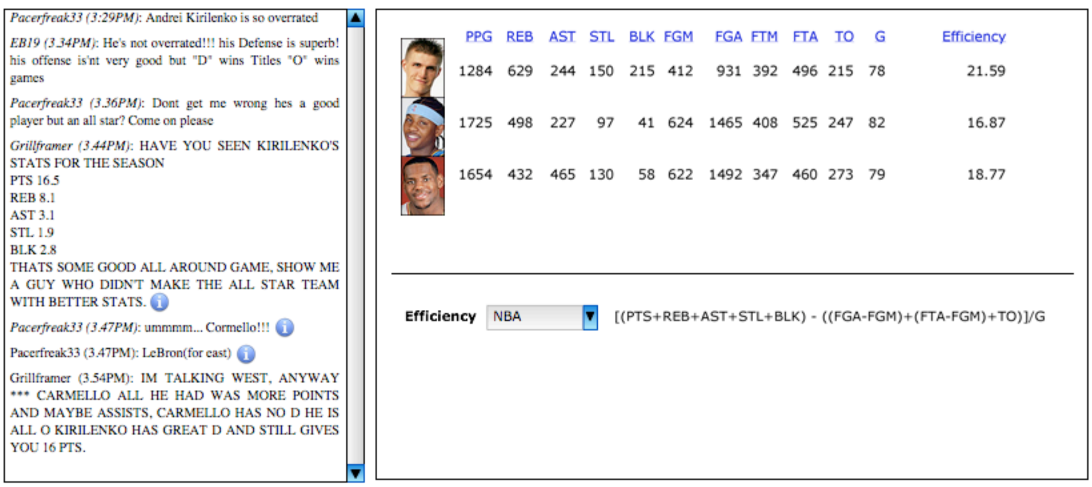


Figure 4: A possible design for a hybrid communications/data analysis space. Players would drag images of athletes into the space on the right. These icons would contain all statistical data related to the athlete allowing players to view the numbers as a spreadsheet or other visual representations. Players would also be able to compare athletes by different efficiency measures.

STEM Content

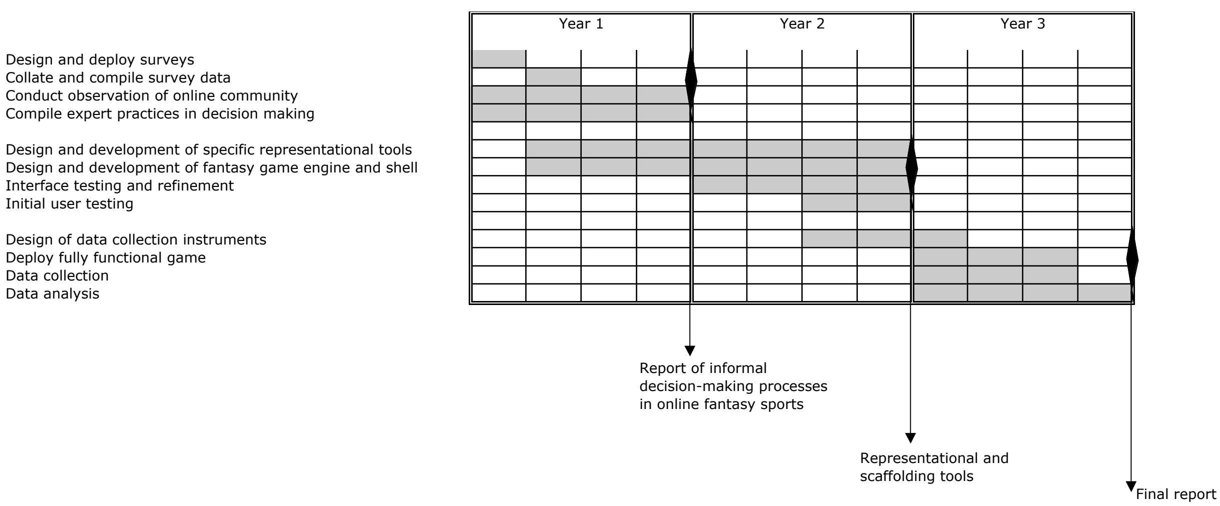
Our objective is to help people learn how mathematics can be used to inform decision-making. Many of the standards articulated by the National Council of Teachers of Mathematics (NCTM, 2000) resemble the strategies that we will support in our fantasy game designs (see Table 1). We will refer to these skills when studying and classifying mathematical practices during observations of players.

Table 1: Grade 9-12 NCTM standards to be supported in our fantasy sports environments.

Data Analysis & Probability	**Problem Solving**
Formulate questions that can be addressed with data Select and use appropriate statistical methods to analyze data Develop and evaluate inferences and predictions based on data	Build new mathematical knowledge through problem solving Apply and adapt appropriate strategies to solve problems Monitor and reflect on the process of mathematical problem solving
Communication	**Representation**
Organize mathematical thinking through communication Communicate mathematical thinking coherently to peers and others Analyze and evaluate the mathematical thinking and strategies of others	Create and use representations to organize, record, and communicate mathematical ideas Select, apply, and translate among mathematical representations to solve problems Use representations to interpret mathematical phenomena

Timeline

A timeline for the development of the primary and secondary deliverables appears below. To maximize efficiency, design, development, and refinement of the informal environment occurs concurrently. In Year 1, we will gather and collate data to describe informal math practices and learning in existing fantasy sports environments, while concurrently developing our own online fantasy sports environment. The descriptive report will serve to enhance design of the environment by allowing us to identify, develop, and integrate appropriate scaffolding in the guise of representational tools. Year 2 involves the iterative refinement of these tools, as well as the initial design of data collection instruments to assess impact. In Year 3, we will deploy the environment and concurrently gather data for evaluating impact.



Results of Prior NSF Support

Brian K Smith—REC #0302169 (2/2000-8/2005; $499,304)
Title: CAREER: Broadcast and the Bits: Enhancing Educational Television with Digital Justification

The original goal for Smith's CAREER proposal was to fuse children's television programming with collaboration tools to promote conversations between parents and children (Smith, Blankinship, & Lackner, 2000). The scope of the proposal was extended to think more generally about encouraging observation and interpretation of visual content in formal and informal environments. This led to the development of a methodology for learning with "imagery as data", supporting three completed master's theses (with a fourth in progress) and a PhD student. Findings from the work have been published in conference proceedings and journals (Albayrak & Smith, 2004; Blankinship et al., 2004; Frost, Albayrak, & Smith, submitted; Frost & Smith, 2001; Frost & Smith, 2002; Frost & Smith, 2003; Smith & Blankinship, 2000; Smith et al., 2000; Smith, Frost, Albayrak-Karahan, & Sudhakar, submitted).