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ARTICLE

Motivational Influences of Using Peer Evaluation in Problem-Based Learning in Medical Education

Sara Abercrombie (Northern Arizona University), Jay Parkes, and Teresita McCarty (University of New Mexico)

This study investigates the ways in which medical students' achievement goal orientations (AGO) affect their perceptions of learning and actual learning from an online problem-based learning environment, Calibrated Peer Review™. First, the tenability of a four-factor model (Elliot & McGregor, 2001) of AGO was tested with data collected from medical students (N = 137). Then, a structural regression model relating the factors of AGO to students' perceptions of grading fairness, judgments of learning, and scoring accuracy was tested. The results indicate that student engagement and success in diagnosing a patient's presentation using a peer feedback-rich web-based PBL environment is somewhat dependent on student motivation. Theoretical and practical implications, in terms of problem-based learning environments in medical education, are discussed.

Keywords: medical education, achievement goal orientation, mastery goals, performance goals, judgments of learning, grading fairness, PBL, patient notes, structural equation modeling, Calibrated Peer Review

Introduction

The motivation for learning in problem-based learning (PBL) has been well researched at the level of the tutorial group where students are motivated to learn by interactive discussion of an interesting problem (Dolmans & Schmidt, 2006). This study looks at individual motivation to achieve in a PBL setting using an electronic learning platform. Calibrated Peer Review™ (CPR) is a web-based, writing-centered learning and peer-evaluation system that can be adapted for use in any discipline (Chapman & Fiore, 2001). The use of CPR in the current study engaged students in the learning processes characteristic of problem-based learning (PBL), including providing an authentic simulated experience modeling professional practice with high-fidelity, engagement in ill-defined problem solving, and reflection (Barrows, 1996). CPR is an example of how PBL can be used in an online context; additionally, since it provides an electronic record, it has the potential to provide insight into both the learning processes and achievement outcomes of PBL.

In this study, CPR was used for medical students' note writing about patients during an Objective Structured Clinical Exam (OSCE). Research suggests that the way that students approach PBL environments might be affected by motivational characteristics, such as achievement goal orientation (Crommelinck & Anseel, 2013; Scott, 2014; Teunissen et al., 2009). The purpose of this investigation was to test whether achievement goal orientation is predictive of motivational and learning processes occurring during CPR cases, including perceptions of grade fairness, judgments of learning, and scoring accuracy.

Problem-Based Learning and Calibrated Peer Review

Problem-based learning (PBL) has been utilized in medical education for nearly a half-century, in order to provide a more student-centered learning environment compared to the traditional lecture-based curricula (Barrows, 1996); and although results are mixed, some research indicates that PBL is an effective means of promoting long-term retention and skill-oriented application (Mamede, Schmidt, & Norman, 2006; Strobel & van Barneveld, 2009). In the typical PBL environment, groups of students work collaboratively to address a meaningful problem over several tutorial sessions, and learning occurs through the exchange of possible solutions with peers and with the guidance of a tutor (Barrows, 1996; Loyens, Magda, & Rikers, 2008). Undergirding this process are several core characteristics that serve as the defining features of PBL. Specifically, PBL environments are student centered, focus on ill-structured problems, support interdisciplinary

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inquiry, incorporate collaboration, include tutor guidance during the problem-solving process, offer opportunities for the reevaluation and reformulation of the problem space, include self- and peer-assessment, include an opportunity for self-reflection, and focus on problems and skills that have real-world value (Barrows, 1996; Savery, 2006).

The web-based CPR system was initially designed to encourage more in-depth writing assignments for large lecture-based science classrooms (Chapman & Fiore, 2001). When it is used to address ill-structured problems, CPR contains the essential characteristics and processes of a PBL environment, though it takes place over several sessions in a computer environment rather than the traditional classroom environment of the tutorial. Specifically, students are presented with a problem or assignment that they must first address individually. Next, they enter a calibration stage, where they see problem solutions of varying quality from faculty that they must individually evaluate and rate. Then, they review anonymous peer work, where they provide feedback and evaluation. Following engaging in peer review, students revisit their original work, and are required to engage in self-reflection and self-evaluation. Finally, students receive feedback on their own work provided by peers, along with a composite grade that is comprised of scores from calibration accuracy with faculty and peers, ratings of their individual notes, and self-ratings of their original work. The CPR system is at once an evaluation tool and a learning tool, since students do receive scores, but also are given the opportunity to develop problem solutions and revise their own thinking. Researchers have tested the efficacy of CPR in various educational contexts, and have found learning gains in engineering, biology, physics, mathematics, chemistry, and medical educational contexts (Carlson & Berry, 2008; Chamely-Wiik, Galin, Kasdorf, & Haky, 2009; Gerdeman, Russell, & Worden, 2007; Gunersel & Simpson, 2009; McCarty et al., 2005).

In the current study, CPR was used with third-year medical education students during an OSCE as they engaged in patient note writing (see Table 1). The first step involved a simulated patient encounter. In this step, the students individually evaluated an actor posing as a patient with symptoms and findings from which they had to generate a clinical differential; this met the characteristics of an ill-structured problem with real-world value to the students. Next, the students were given 10 minutes to use their prior knowledge to individually compose a patient note. Students were instructed that the note was to be limited to the history and physical examination information needed to synthesize the most relevant differential and to generate the appropriate evaluation-focused treatment plan. While writing, then, the students repeatedly differentiated essential from nonessential information. Following note writing, students entered the calibration stage where they were individually presented with three notes, of varying quality, that were composed by faculty members and based on the same patient encounter. This step in the process was a type of tutor guidance and modeling during problem solving. In addition, since the faculty notes were not necessarily exemplars, this form of guidance could prompt new thinking or directions for the students, similar to what occurs during inquiry-based instruction. During the calibration stage students answered guiding questions and applied a global rating scale to each of the calibration notes. Students then received detailed feedback about how closely their judgments conformed to those of the faculty. Students also had the opportunity to read faculty explanations of why specific information was important and why some approaches may have been better than others. Following calibration, students used the same guiding questions and rating scale to evaluate three randomly selected, anonymous, peer-written notes about the same patient encounter. During this step, students also were required to provide narrative feedback to their peers. Following peer-evaluation, students used the same tools to perform self-assessment. After writing a patient note

Table 1. The Calibrated Peer Review assignment steps applied to patient note writing.

CPR steps	For the patient note-writing assignments students…
Stimulus	Perform a patient evaluation in a simulated clinical setting
Write	Write a patient note in the CPR web environment
Calibrate	Use a series of questions to evaluate three faculty-prepared patient notes that are of varying quality about the same patient-clinician encounter
Feedback from Faculty	Receive information about how similar their calibration note responses and scores are to those of faculty and read explanations of what should and should not be included in the patient note
Peer Review	Use the same series of questions to evaluate three randomly selected, anonymous, peer-written patient notes on the same patient-clinician encounter
Self-Assessment	Use the same series of questions to perform a self-evaluation on own patient note
Feedback from Peers	Review the narrative comments from their peers and their scores for each step of the assignment

each student read six other analyses of the same patient. This sequence actively engaged students in informed self-reflection and provided another opportunity for problem reevaluation. Students were then given a composite score based on the quality of their original note, their competence in rating the calibration notes (i.e., faculty notes) and peer notes, and their ratings of their original note.

As research has shown that, compared to traditional instruction, PBL is effective in promoting long-term retention and skills, researchers have called for more attention to the study of the interaction between the learning environment and student characteristics in order to better understand how to optimize PBL environments for individual learners (Scott, 2014; Strobel & van Barneveld, 2009). The current study addresses this call by examining the role that individual motivational characteristics play in influencing engagement with and learning from the CPR model of the PBL learning environment.

Achievement Goal Orientation and Peer Assessment Systems

Achievement goal orientation is a motivational characteristic that describes the focus of individuals' goals during learning and has historically been theorized by two positions, namely, mastery focused or performance focused (Payne, Youngcourt, & Beaubien, 2007). Researchers originally conceptualized mastery goals as a superior goal orientation compared to performance goals. Evidence has supported this view, in that mastery goals have been consistently related to a wide variety of positive educational outcomes, including greater persistence, situational interest, help seeking, self-directed learning, positive emotion, task value, and engagement in collaboration (Senko, Hulleman, & Harackiewicz, 2011). However, both mastery and performance goal orientations show mixed relationships to performance outcome (Senko et al., 2011), though some researchers note that for complex tasks, mastery goals are related to higher performance (Belenky & Nokes-Malach, 2011). In contrast, research on the influence of performance goals shows a less consistent relationship to outcomes. Performance goals are sometimes associated with lower achievement on tasks, and sometimes appear to be related to other outcomes such as test anxiety and low effort, prompting researchers to more closely examine the dimensions of performance goals (Senko et al., 2011).

To more thoroughly explain achievement goals, researchers have expanded goal orientation to include not only how individuals frame goals during learning, but also the valence of individual approaches to learning (Elliot & McGregor, 2001). Specifically, this 2X2 Achievement Goal Orientation (AGO) framework has four positions, mastery-approach, mastery-avoidance, performance-approach, and performance-avoidance. Individuals with mastery goals define competence in terms of knowledge acquisition, whereas individuals with performance goals conceptualize competence in terms of relative achievement compared to others. Those with approach goals view learning from a positive valence, where they are approaching success, whereas those with avoidance goals view learning from a negative valence, where they are avoiding failure. Theorists have suggested that avoidance goals, both performance and mastery, are particularly detrimental to learning, and lead to negative learning behaviors such as disengagement and anxiety (Senko et al., 2011). However, while the 2X2 AGO framework has been empirically tested with some populations, it is not yet clear whether the same conceptual structure will fit all groups or describe how individuals approach learning in all contexts (Muis & Winne, 2012). For example, in an interview-based study conducted with medical students, individuals rarely mentioned performance goals (Horowitz, 2010), evidence consistent with other similar studies (Brophy, 2005). Furthermore, the conceptualization of mastery-avoidance goals is relatively new, and has not been thoroughly explored, psychometrically or in terms of its relation to other constructs, such as achievement (Payne et al., 2007). Therefore, one objective of the current study is to test the factor structure of AGO with medical students.

Though PBL and collaborative peer evaluation systems such as CPR have generally been shown to have a positive influence on learning outcomes (Strobel & van Barneveld, 2009; van Zundert, Sluijsmans, & van Merriënboer, 2010), student perceptions of such environments are less clear. Some evidence from the medical and other professional fields shows mixed results regarding students' attitudes toward peer assessment and evaluation (Patton, 2012; van Zundert et al., 2010). Similarly, while little research has directly investigated the influence of achievement goals on engagement in PBL (Scott, 2014), theorists hypothesize that students with mastery goals are more open to collaborative learning environments, and those with performance goals approach such environments with greater caution and reserve (Senko et al., 2011). In a recent multilevel analysis examining the design effects of the PBL environment, Scott (2014) tested whether AGO predicts several outcomes in a PBL environment, including self-directed learning (SDL) and perceptions of the learning environment. Results indicate that mastery orientation positively predicts SDL, and that performance goal orientation is negatively related to student reactions to the PBL environment. However, this analysis did not include the valence components of achievement goals, so it is not clear how approach or avoidant goals influence engagement in PBL. These results encourage greater research attention to the ways in which motivational factors, such as goal orientation, affect learning and engagement in PBL environments.

The Current Study

The purpose of the current study is to examine whether AGO predicts perceptions of grade fairness, judgments of learning, and scoring accuracy when engaged in CPR. Research suggests that individuals with strong performance goal orientations are more likely to view achievement situations as threatening, and are concerned about appearing competent (approach) or not letting others see them fail (avoidant) (Payne et al., 2007; Senko et al., 2011). Therefore, it is hypothesized that performance-approach and performance-avoidant orientations will positively relate to feelings among medical students that scores from peer assessment are not fair, but there is no hypothesized relationship between mastery orientations and perceptions of grade fairness. Research also suggests that mastery-oriented students actively engage with collaborative environments and seek out feedback, since feedback facilitates learning, whereas performance-oriented students are less inclined to seek feedback or are more guarded in such environments, since negative feedback is associated with the cost of appearing incompetent in front of others (Crommelinck & Anseel, 2013; Gardner, 2006; Payne et al., 2007; Senko et al., 2011). Since the CPR system requires collaboration, in that it requires students to review each other's work and provide each other with detailed formative feedback, mastery orientation is hypothesized to relate to positive judgments of learning and both performance-goal orientations are hypothesized to relate to negative judgments of learning from CPR cases. Finally, as performance on complex tasks has been shown to positively relate to mastery orientation and negatively relate to performance orientation (Belenky & Nokes-Malach, 2012; Payne et al., 2007), it is hypothesized that increased scoring accuracy will be positively related to mastery orientation and negatively related to performance orientation.

Method

Sample and Procedure

A total of 137 third-year medical students participated in the study, which included writing three clinical notes employing the CPR system, completing the Achievement Goal Questionnaire, and completing the Calibrated Peer Review questionnaire. Data were collected in 2008-2009. Expected-maximum (EM) multiple imputation (Kline, 2011) was used to address missing data (approximately 3.5%) for the variables of interest, thereby allowing for analysis of all participants' scores and ratings.

Instruments

Achievement Goal Questionnaire. A context-specific version of the 12-item AGO scale (Elliot & McGregor, 2001) was created to focus on students' most recent clerkship by replacing "class" with "clerkship" for the items (e.g., *I just wanted to avoid doing poorly in the clerkship*). No other modifications to the AGO measure were made, and all items were measured on a seven-point Likert scale (1 = Not at all true of me, 7 = Very true of me).

To test the four-factor model of AGO with the medical students, a confirmatory factor analysis using LISREL 8.8 was conducted and was tested against four competing models identical to those tested by Elliot and McGregor (2001). The analyses were based on the correlation matrices, and the solutions were based on maximum likelihood estimates. The four-factor model hypothesizes separate factors for Mastery Approach, Performance Approach, Mastery Avoidant, and Performance Avoidant. Alternative models included: 1) Trichotomous Model A, where performance-approach and performance-avoidant models load on separate factors, and mastery-approach and mastery-avoidant models load on a single factor together; 2) Trichotomous Model B, where mastery-approach and performance-approach items load on separate factors, and mastery-avoidant and performance avoidant items load together on a single factor; 3) A Mastery-Performance Model, where mastery-approach and mastery-avoidant items load on a single factor, and performance-approach and performance-avoidant items load on a single factor; 4) An Approach-Avoidant Model, where mastery-approach and performance-approach items load on a single factor and mastery-avoidant and performance-avoidant items load on a single factor. Results indicated that the four-factor model (see Figure 1) had acceptable fit, and none of the alternative models provided good fit for the data (see Table 2).

Calibrated Peer Review Questionnaire. Judgments of Learning and Perceptions of Grading Fairness were assessed using a 16-item attitudes about CPR questionnaire, measured with a four-point Likert scale (1 = strongly disagree to 4 = strongly agree). The four-point Likert scale was chosen in order to avoid the neutral response option present in the five-point Likert scale. In total, seven items addressed perceptions of grading fairness (e.g., *I prefer faculty assessment to peer assessment because I worry about the standards of peer judgment*) and nine items addressed judgments of learning from CPR (e.g., *CPR helps me develop my clinical reasoning*). Higher scores on the perceptions of grading fairness scale signal greater distrust in the fairness of the CPR system, whereas higher scores on the judgments of learning items signal a greater sense of the value of CPR for learning.

Table 2. Fit indices for the Four-Factor Model of achievement goal orientation and four alternative models.

	χ^2 (*df*)	RMSEA (90% CI)	CFI	TLI/NNFI
Four-Factor Model	86.29 (48)	.07 (.042; .096)	.947	.927
Trichotomous A*	169.80 (51)	.12 (.098; .142)	.835	.786
Trichotomous B*	207.08 (51)	.146 (.125; .168)	.783	.719
Mastery-Performance*	323.23 (53)	.193 (.173; .214)	.624	.532
Approach-Avoidant*	293.95 (53)	.176 (.156; .197)	.665	.583

* Indicates significantly worse fit compared to the Four-Factor Model as indicated by $\Delta\chi^2$ test.

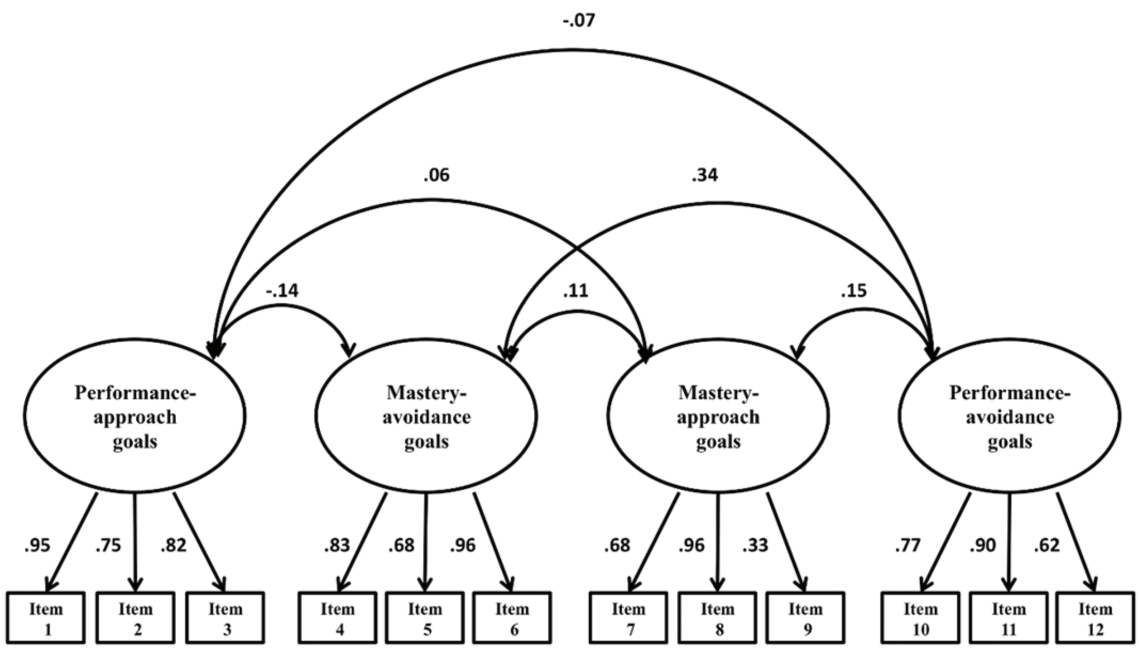


Figure 1. The factor structure of achievement goal orientation for medical students reported in standardized coefficients.

Both measures were tested using principle axis exploratory factor analysis with a varimax rotation, and each yielded a single factor solution. The Kaiser rule, where factors with eigenvalues greater than one are retained, and the interpretation of the scree plot, where the number of points before the plot levels off, were used to indicate the number of factors to be retained. The one factor solution accounted for 42% of the variance for the Judgments of Learning scale, and 22% of the variance for the Perceptions of Grading Fairness scale. Though only a small amount of the total variance was accounted for, the Perceptions of Grading Fairness scale was retained in subsequent analyses due to its conceptual importance in the current the study. In order to obtain more reliable estimates and to optimize the measurement structure of the constructs, three item parcels for each construct were constructed by averaging highly correlated items with each other (Little, Cunningham, Shahar, & Widaman, 2002). Item bundles were shown to be reliable (Cronbach's α = .824 for Judgments of Learning; Cronbach's α = .585 for Perceptions of Grading Fairness).

Scoring accuracy. Accuracy of scoring within CPR was measured with three scores; the Calibration Deviation, which is the average absolute deviation between the students' global rating and the faculty ratings of the calibration notes; the Review Deviation, which is the average absolute deviation between the students' global rating of their three peers and the weighted average rating given to those three peers; and the Self-Assessment Deviation, which is the absolute deviation between the students' self-assessment global rating and the weighted average rating given to their note by three peers. Since this construct is based on deviation scores, smaller values represent greater accuracy in scoring.

The means, standard deviations, and latent correlations between constructs based on the full measurement model are reported in Table 3.

Results

Structural equation modeling was employed to test the relationship between AGO factors, Judgments of Learning, Perceptions of Grading Fairness, and the Scoring Accuracy results. First, a confirmatory factor analysis (CFA) model, including the four factors of AGO, Judgments of Learning, Perceptions of Grading Fairness, and Scoring Accuracy variables, was tested to evaluate measurement of the latent constructs. Results indicated acceptable fit, χ^2 (168, N = 137) = 248.409 (p < .001); RMSEA = .0558 (90% Confidence Interval, 0.0386; 0.0713); CFI = 0.934; TLI/NNFI = 0.917. Next, we fitted a structural regression model in which the four factors of AGO predicted Judgments of Learning, Perceptions of Grade Fairness, and Scoring Accuracy. Standardized and unstandardized latent regression coefficients of the four AGO factors predicting the three outcome variables are shown in Table 4. The structural regression model was trimmed one path at a time, to ensure that overall model fit did not diminish as nonsignificant paths were removed. The final trimmed model is shown in Figure 2.

Results indicate a significant relationship between medical students' performance-approach goals and perceptions of grading fairness in CPR, with stronger performance-approach goals related to greater perceptions of unfairness. Performance-approach goals significantly related to scoring accuracy, so that the stronger the performance-approach goals, the less calibrated with faculty-, peer-, and self-assessment in CPR. Higher mastery-approach goals were significantly related to greater perceptions of learning value of the

Table 3. Means, standard deviations, and latent correlations between study constructs from full measurement model CFA.

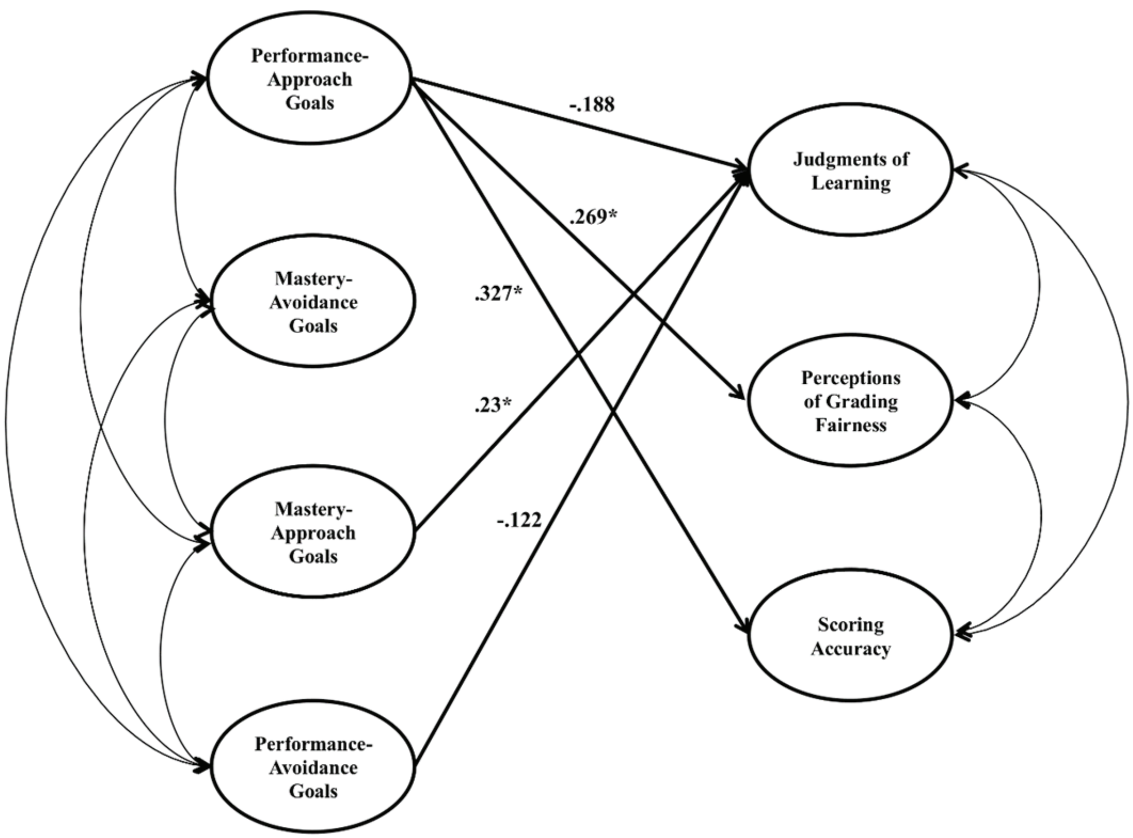
	Construct						
	M (*SD*)	2	3	4	5	6	7
1. Performance-Approach Goals	3.98(1.62)	-0.14	0.06	-0.07	-0.16	0.27*	0.32*
2. Mastery-Avoidance Goals	4.61(1.37)		0.11	0.34*	-0.03	-0.05	0.05
3. Mastery-Approach Goals	5.96(0.82)			0.15	0.22*	-0.03	-0.10
4. Performance-Avoidance Goals	3.91(1.70)				-0.08	0.00	-0.11
5. Judgments of Learning	2.89(0.43)					-0.82*	-0.27*
6. Perceptions of Grading	2.46(0.38)						0.56*
7. Scoring Accuracy	0.98(0.23)						

* $p < .05$; Potential scores ranged from 1 to 7 on AGO factors (i.e., Performance-Approach Goals, Mastery-Avoidance Goals, Mastery-Approach Goals, Performance-Avoidance Goals), 1 to 4 on Judgments of Learning and Perceptions of Grading. In this study, Scoring Accuracy ranged from .55 to 1.57.

Table 4. Unstandardized and standardized latent regression coefficients.

	Judgments of Learning		Perceptions of Grading		Scoring Accuracy	
	B	β	*B*	β	*B*	β
Performance-Approach Goals	-0.21*	-0.20*	0.28*	0.27*	0.37*	0.34*
Mastery-Avoidance Goals	-0.05	-0.05	-0.02	-0.02	0.16	0.15
Mastery-Approach Goals	0.27*	0.26*	-0.06	-0.05	-0.13	-0.12
Performance-Avoidance Goals	-0.12	-0.12	0.04	0.03	-0.12	-0.11

*$p < .05$



*$p < .05$; Model fit: $\chi^2(175, N=137) = 251.653$, $p < .001$; RMSEA = .0529 (.0354; .0685); CFI = .937; TLI/NNFI = .924

Figure 2. Final structural regression model with standardized regression coefficients.

CPR system. No significant relationships between either of the avoidance goal orientations and any of the outcomes were identified, though the final model does include a negative correlation between performance avoidance and judgments of learning.

Discussion

Results suggest that the 2x2 framework for achievement goal orientation is tenable for the medical student population, and that individual goal orientations are predictive of engagement with a PBL environment. Specifically, greater mastery-approach orientation was associated with higher judgments of learning among the medical students, indicating that holding mastery-approach goals increases the perceived learning value of such a PBL environment. This result is consistent with other similar findings from the AGO literature that show that individuals with mastery goals place a higher learning value on collaborative learning experiences (Senko et al., 2011). In contrast, performance-approach goals were associated with more negative judgments of scoring fairness, thereby confirming that performance approach is maladaptive to perceptions of the PBL environment. These results are consistent with evidence within medical education showing that residents with higher perceived feedback cost were less likely to engage in feedback-seeking behavior (Teunissen et al., 2009).

In terms of learning outcomes, we found that performance-approach goals positively related to scoring accuracy, so that the higher the performance-approach goal, the less calibrated students were to faculty-, peer-, and self-ratings of note quality. We argue that the deviation scores are a good indicator of performance in CPR. The deviation score was comprised of three different components, calibration with faculty note scores, calibration with peer note scores, and calibration with self. Part of becoming a successful practitioner in medicine is being able to successfully recognize key features of a presenting patient's history, recognize the likely diagnoses for that patient, and come up with a tenable evaluation plan, all of which are key components to a good patient note, and are incorporated in the faculty- peer-, and self-calibration scores. Further, critically examining one's own professional judgment in the face of peer judgment is a key component to learning how to become an accurate medical practitioner. The self-assessment score reflects this skill, in that students had to produce an accurate review of their own patient note after they reviewed the notes of others. The overall calibration score is therefore a skill measure of a complex task, and our results are consistent with research examining similar outcome variables (Belenky & Nokes-Malach, 2012; Strobel & van Barneveld, 2009).

Theoretical and Practical Implications

A great deal of research on PBL has focused on comparing PBL and traditional learning environments, typically lecture-based environments. This approach has yielded a great deal of useful information, but there is still a strong need to examine the complex relationships between individual, social, and design influences on learning and engagement with PBL (Scott, 2014; Strobel & van Barnesveld, 2009). The current study provides insight into the ways in which the dimensions of one motivational construct, achievement goal orientation, interacts with the PBL environment. The results show that attitudes toward PBL, along with processes of engagement with PBL, are affected by individual motivation. Practically, these results indicate that some students, depending on their motivations, might be more successful in PBL environments than others. Educators might therefore need to consider students' individual motivations in instructional design, and encourage students to foster adaptive motivational goals such as mastery-approach goals.

Theoretically, this research supports the 2x2 factor structure of AGO (Elliot & McGregor, 2001) and shows that this model of goal orientation can be generalized to medical student populations. Since the majority of research on achievement goal orientations has been conducted outside of post-baccalaureate professional schools, such as medical school, this research extends the knowledge base about the psychometric properties of the four-factor model of AGO. While the avoidance positions did not have great explanatory power for the outcomes we investigated, these results suggest that approach and avoidance positions are distinct, and that when students express these different achievement goals, we might predict different outcomes in terms of learning and engagement. In the current study, performance-approach goals appeared to be the most detrimental for students, so educators might emphasize to students that these goals in particular serve as a barrier when engaging in PBL.

Limitations and Future Directions

In this study, we performed a relatively complex analysis of the data considering the sample size. Therefore, the results should be interpreted with some caution, and the study should be replicated with a larger sample. In addition, due to the small sample size, we were not able to investigate the relationship between AGO factors and all possible outcome variables from CPR. The generalizability of the results might also be limited in that the data were collected at one medical school in the southwestern United States with a history of using a PBL instructional approach. Conducting similar studies with more varied populations of medical students could help delineate the generalizability. Finally, the current study averaged students' performance over three different problem scenarios. Since research suggests that problem complexity might influence the enactment of achievement goal orientations (Senko et al., 2011), future research more explicitly examining problem characteristics and goal achievement could lead to a more fine-grained understanding of how student motivation relates to this learning environment.

The results of the current study indicate that a mastery-approach goal orientation is adaptive for learning in a PBL environment, since higher mastery-approach orientation was associated with greater judgments of learning, whereas performance orientations, particularly performance approach, are less adaptive, leading to the feeling that grading processes are unfair and lower performance. An important question, then, is whether or not achievement goal orientations are stable among learners, or if they vary depending on the task.

In a recent study examining the stability of goal orientation among adult students, researchers found that goal orientation is relatively stable, with the large majority of students reporting identical or very similar goal orientations at two intervals, four months apart (Pulkka & Niemivirta, 2013). Muis & Edwards (2009) also found that overall goal orientation tends to be stable, though there was evidence for some shifting of goal orientation depending on task, and evidence that some of the dimensions (i.e., performance approach) are more stable than others (i.e., mastery approach and performance avoidance). In addition, these theorists posit that rather than the task itself, other antecedents such as fear of failure might better explain goal shifting by task. However, other research suggests that when an educational environment explicitly emphasizes mastery orientation and deemphasizes performance orientation, mastery achievement goals are fostered (O'Keefe, Ben-Eliyahu, & Linnenbrink-Garcia, 2013). This research was conducted with adolescents, and it is not clear whether such environmental changes are practical in medical education environments or with older student populations. Basic research on the mutability of achievement goals for the medical student population is warranted. Also, methods research on the ways in which medical educators can promote mastery-approach goals over performance goals is warranted.

In addition, in the current research study, we described the CPR learning and evaluation environment as an example of an online PBL environment (Chapman & Fiore, 2001). However, we did not thoroughly examine all possible outcome measures that might lend insight into learning in such an environment. With CPR, researchers and educators can track student learning progress, including accessing data on the time spent on different steps of the process, and the thinking processes that are uncovered during learning. These data could lend insight into a number of student thinking processes, including information and feedback seeking, thought refinement and revision, expertise development, and the interaction between problem difficulty and thinking. We believe that there is enormous research potential in a more thorough examination of CPR. Specifically, more research examining CPR in terms of learning processes and outcomes could help the PBL research field better understand student thinking during PBL.

Further, future researchers might examine whether engaging in an online PBL environment such as CPR is truly equivalent to the face-to-face tutorial model typically used for PBL (Loyens et al., 2008). For example, in the CPR environment, students work more independently and asynchronously than they would in the typical tutorial environment, and they are formally evaluated at each step of the process. Plus, their final grade reflects not only individual outcomes but also proficiency in rating others' work. Therefore, the motivational and learning consequences of CPR might vary from those typically occurring with PBL. However, since there is increasing interest in flexible learning environments and electronic platforms that have virtues in the ability to track and assess individual progress (Anderson, Mitchell, & Osgood, 2008), the CPR environment may address a current limitation of traditional PBL techniques (Mamede et al., 2006). Therefore, further exploration into process-oriented environments such as CPR hold particular promise for researchers and educators interested in PBL.

Conclusion

This research indicates that student engagement and success in diagnosing a patient's presentation using a peer feedback-rich web-based PBL environment is somewhat dependent on student motivation. As research on PBL in medical education advances, more attention should be paid to the ways in which individual motivational factors interact with the learning environment, along with the ways in which the overall learning environment fosters specific motivations.

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