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ABSTRACT

The purpose of this study was to investigate the role of perceived problem quality in the relationship between students' (N = 226) achievement goals and autonomous motivation to study in a problem-based learning (PBL) environment. Specifically, the relationships between students' achievement goals (mastery-approach, performance-approach, performance-avoidance, and mastery-avoidance goals), problem quality-related characteristics (triggering interest, familiarity, stimulating collaborative learning, resulting in intended learning objectives, and promoting critical reasoning), and autonomous motivation to study were investigated. The findings indicate that the perceived quality of problems (i.e., familiarity, resulting in intended learning objectives, promoting critical reasoning, and by that triggering interest) fosters autonomous motivation to study and that the perception of this quality is influenced by students' achievement goals. Therefore, the quality of problems and students' achievement goals should be taken into account in a PBL environment.

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Student-centered learning environments such as problem-based learning (PBL) are becoming increasingly popular in education (e.g., Loyens & Rikers, 2011). In PBL, small groups of students work together under the guidance of a tutor. PBL is a form of constructivist learning in which students engage in knowledge construction based on problems that are presented at the start of the learning process (Gijbels, Van de Watering, Dochy, & Van den Bossche, 2005). This first phase of the PBL cycle in which problems are presented and discussed (i.e., initial problem discussion) is followed by a self-guided study phase and a reporting phase.

Problems are descriptions of real-life phenomena or situations in need of explanations and can be presented in a variety of formats, such as a textual format (e.g., a case description, a story, quotes, or a journal article), tables, graphs, short movies, or photos. The quality of problems in PBL is associated with group functioning and achievement (Schmidt & Moust, 2000). In PBL, tutors are important for student learning, and tutors can predict students' study success and attrition based on students' motivation (Wijnia, Loyens, Derous, Koendjie, & Schmidt, 2014). However, problem quality has been shown to have a greater impact on students' learning process when compared to tutor functioning (Van Berkel & Schmidt, 2000).

An important goal of PBL is to enhance students' motivation (Norman & Schmidt, 1992). Because in PBL students encounter the problems at the very start of the learning process, these problems are initially discussed on the basis of limited prior knowledge. The incongruence between their prior knowledge and the knowledge needed to explain the problem should increase students' motivation for independent study (Rotgans & Schmidt, 2014), because students' curiosity will be sparked (Loewenstein, 1994). This curiosity is assumed to result in willingness to do what is necessary in order to learn, because people are naturally inclined to engage in activities that can help them master the subject matter (Deci & Ryan, 2000).

Nevertheless, implementing a PBL environment is no guarantee of success: motivational problems are sometimes reported in PBL environments (Dolmans & Schmidt, 2006), and PBL environments are not necessarily more (or less) effective for students' motivation than lecture-based environments (Galand, Raucent, & Frenay, 2010; Wijnia, Loyens, & Derous, 2011). Likewise, not all problems might be equally effective in promoting motivation (Dolmans, Snellen-Balendong, Wolfhagen, & Van der Vleuten, 1997).

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Furthermore, individual differences between students are often not taken into account in discussions on the effectiveness of PBL environments (Dolmans & Gijbels, 2013).

Research has shown that students differ in the way they perceive their learning environment, and that this perceived learning environment is actually what affects their motivation and achievement (Segers & Dochy, 2001). The direction of achievement goal pursuit is one such important difference, as students' perceptions of their learning environment are filtered through their achievement goals (Tapola & Niemivirta, 2008; Wolters, 2004). The current study, therefore, investigated the relationship between students' achievement goals and motivation in a PBL setting, taking into account the possible mediating effect of students' perceptions of the quality of the problems.

Achievement Goal Orientation and Motivation

An important framework for understanding motivation in educational contexts stems from achievement goal orientation theory (Dweck & Leggett, 1988). Four types of achievement goals are usually distinguished (Elliot & McGregor, 2001). Individuals with mastery-approach (MAP) goals tend to focus on developing competence or task mastery (e.g., learning a new computer program), whereas individuals with mastery-avoidance (MAV) goals tend to focus on avoiding deterioration of competence or falling short of one's own standards (e.g., avoiding a failure to learn everything there is to learn of this new computer program). Individuals with performance-approach (PAP) goals tend to focus on showing competence to others (e.g., winning a competition), whereas individuals with performance-avoidance (PAV) goals tend to focus on avoiding a show of incompetence compared to others (e.g., avoiding being the worst in a competition). Correlations between the different goals are low (.06, MAP-PAV) to moderate (.36, MAV-PAV; Huang, 2012). Someone's achievement goal orientation is a relatively stable, trait-like dispositional variable, and individual differences in students' achievement goals can affect their motivation to study (e.g., Elliot, Murayama, & Pekrun, 2011).

According to self-determination theory (SDT; Deci & Ryan, 2000), students can have multiple motives for engaging in study-related activities that can be high or low in quality. Autonomous motivation is considered a high-quality type of motivation. Autonomous motivation involves the experience of choice and psychological freedom. Autonomously motivated students study because the tasks are interesting (i.e., intrinsic motivation) or important to achieve a life goal (i.e., identified motivation). Controlled motivation is considered lower in quality and involves the experience of being pressured either by others (i.e., external motivation) or from within (i.e., introjected motivation).

The positive relationship between MAP goals and high quality, autonomous motivation is well-established (e.g., Rawsthorne & Elliot, 1999). In contrast, individuals with PAP and PAV goals are concerned about the impressions of others, which is likely to be associated with lower autonomous motivation (e.g., Elliot et al., 2011). For students with MAV goals, studying is not as pleasurable as it could be for students with MAP goals, but they study because of the benefits that derive from their behavior for their own self-perception (Baranik, Stanley, Bynum, & Lance, 2010); as a result, students with MAV goals are likely to have some autonomous motivation, but less than students with MAP goals.

Theory and research have postulated that the quality of motivation is influenced not only by individual differences in achievement goals, but also by the features of a learning environment, such as the meaningfulness or interestingness of tasks (Bruner, 1961; Deci & Ryan, 2000). Sansone and Thoman (2005) argued that task characteristics could be the missing link between goals and motivation. Students' perceptions of the learning environment differ as a function of their achievement goals (e.g., Tapola & Niemivirta, 2008). For example, people's achievement goals have been associated with finding value in certain tasks and activities (Pintrich, 2003). One of the assumptions of PBL is that it enhances students' autonomous motivation (Norman & Schmidt, 1992), as working on meaningful but unclear problems sparks curiosity, resulting in motivation for studying and subsequent independent studying that goes beyond just studying for an exam (Bruner, 1961, 1967). Therefore, it could be assumed that the relationship between achievement goals and autonomous motivation might be partially explained by students' perception of a problem's quality, such as whether the problem triggers interest, is familiar to them, promotes collaborative learning, results in learning objectives for self-guided study, and stimulates critical reasoning.

Quality of Problems in PBL

In PBL high demands are placed upon the design of the problem, because problems are at the heart of PBL (Hung, 2006; Jonassen & Hung, 2008). In other words, the quality of problems is key to the success of PBL. The studies by Hung (2006; Jonassen & Hung, 2008) offer very useful suggestions for systematically designing problems, but they are theory-based, and as far as we know, not tested empirically. Furthermore, the quality of a problem is determined not only by its content, but also by how the problem facilitates group processes and students' self-guided study (Dolmans et al., 1997; Wijnia et al., 2011). Finally, students are the end users of the problems, as problems are the starting point of their learning process.

It can therefore be assumed that their rating of problems is likely to provide a valuable insight into what kinds of problems could be considered to be of high quality.

A factor analysis (Sockalingam, Rotgans, & Schmidt, 2012) investigating the different quality aspects found in previous studies (e.g., Des Marchais, 1999) revealed that the quality of a problem can best be determined by five aspects: the extent to which a problem 1) triggers interest, 2) is familiar to students, 3) promotes collaborative learning, 4) results in the intended learning issues, and 5) stimulates critical reasoning. It is assumed that when problems meet these criteria, they are more likely to result in autonomous motivation to study, because high-quality problems will make learning activities more challenging, enjoyable, or beneficial for personal goals (cf. Deci & Ryan, 2000). The way students perceive those five aspects—and thereby the subjective quality of a problem—can differ between students (e.g., Sockalingam, Rotgans, & Schmidt, 2011; Soppe, Schmidt, & Bruysten, 2005). In this study, we examine whether the perceived quality of a problem could be influenced by individual differences in achievement goals (Pintrich, 2003; Tapola & Niemivirta, 2008). That is, the value of learning, the perception of a task, the evaluation of performance, and the focus on information processing might be different for students as a result of their achievement goals. Below we discuss the five indicators of problem quality and how they might be affected by differences in students' achievement goals.

Interest

Problems are assumed to trigger students' interest by making students aware of a gap in their knowledge, and this interest acts as a driving force for learning (Schmidt, Rotgans, & Yew, 2011). However, individual differences in achievement goals might affect students' perception of interest in a problem. Students with MAP goals, compared to students with MAV, PAP, or PAV goals, may be more likely to experience higher levels of individual interest, because their aim is to develop their competence. In line with this line of argument, Hulleman, Durik, Schweigert, and Harackiewicz (2008) demonstrated that task characteristics such as perceived utility and interestingness mediated the effect of MAP goals on subsequent individual interest, motivation, and performance.

Familiarity

According to Soppe, Schmidt, and Bruysten (2005, p. 273), familiarity with a problem is "the extent to which the student has had any previous experience with the events or phenomena described in the problem." Unfamiliar problems may be less effective because students cannot relate to them and as a result have shorter and less productive group discussions (Schmidt et al., 2011). Again, individual differences in achievement goals might affect students' perception of problem familiarity. People with MAV or PAV goals prefer to avoid novelty (Elliot & McGregor, 2001) and therefore might prefer familiar problems that can help them to achieve their goal of avoiding incompetence. Students with PAP goals focus on outperforming others and therefore would also prefer easy and familiar tasks (Winters & Latham, 1996). In contrast, students with MAP goals prefer complex and unfamiliar tasks; therefore, familiarity of a problem seems less likely to be important for students with MAP goals. So, for students who focus on developing competence or task mastery, familiarity will less likely mediate the effect of MAP goals on autonomous motivation.

Collaborative Learning

Collaborative learning concerns collective group-learning activities: bringing prior knowledge to the table, discussing and questioning each other's ideas, and working together toward a common goal. This shared responsibility and commitment to learning is an essential factor for success in PBL (e.g., Dolmans & Schmidt, 2006). Collaborative learning in PBL settings can help students to feel more connected to their peers, and as a result, positively influence motivation, effort, and persistence (Wentzel, 1999). Students have indeed indicated that collaborative learning was one of the motivating elements of the PBL environment (Wijnia et al., 2011). However, the value of collaborative learning might differ for students as a result of their achievement goals. Students with PAP, PAV, and MAV goals are more likely to withdraw from a task when facing difficulties, sit back, and avoid help seeking (Elliot & McGregor, 2001). For those students, collaborative learning could be of value only when there are no difficulties. In contrast, collaborative learning could be motivating for students with MAP goals, when other students in their PBL group add new knowledge or insights into their own learning process and help them when facing difficulties (Karabenick, 2003). We therefore expect that collaborative learning will likely mediate the effects of MAP goals on autonomous motivation.

Learning Objectives

In the first phase of the PBL cycle, students actively identify learning objectives arising from the problem. Learning objectives are the issues emerging during the initial problem discussion that require further explanation, and as such are an important predictor of self-guided study and the depth of reporting after self-guided study (Van den Hurk, Dolmans, Wolfhagen, & Van der Vleuten, 2001). Low-quality problems cause difficulty in generating learning objectives and subsequent self-guided study, and as a result, the preset objectives of a course are not met (Dolmans, Gijselaers, Schmidt, & Van der Meer, 1993). In a qualitative study, students indicated that the extent to which a problem leads to clear learning objectives was the most important characteristic of high-quality problems (Sockalingam & Schmidt, 2011). Learning objectives are the starting point for students' self-guided study, and it might be assumed that the learning activities in themselves are determined by the goals students try to achieve. For example, students who in their pursuit of PAP goals aim at being the best will put a lot of effort into their self-guided study when they expect that they will be able to show others how smart they are in the reporting phase of the PBL-cycle. However, individual differences in achievement goals will be less likely to influence students' perception of the quality of problems when it comes to generating intended learning objectives, because regardless of their goals, all students need learning objectives to start their search for literature.

Critical Reasoning

Barrows (1985; Barrows & Tamblyn, 1980) held that the objective of PBL is to develop and transfer critical reasoning and thinking skills; indeed, improvement in critical reasoning and thinking is higher in PBL environments compared to lecture-based learning environments (e.g., Tiwari, Lai, So, & Yuen, 2006). Critical reasoning or critical thinking is defined as "the process of actively and skillfully conceptualizing, applying, analyzing, synthesizing, and/or evaluating information […] as a guide to belief and action" (Scriven & Paul, 1987, n.p.). Individuals with MAP goals prefer to focus on deep processing of information and spend a lot of time and effort on a task in order to master the task (Elliot & McGregor, 2001). Therefore, critical reasoning resulting from a problem might be important for students with MAP goals. In contrast, avoidance (MAV and PAV) and PAP goals are related to surface processing of information (Elliot, McGregor, & Gable, 1999), and therefore for those students, promoting critical reasoning would be less likely to mediate the effects of achievement goals on autonomous motivation.

Hypothesized Model

Theory and previous research have postulated that the quality of motivation is influenced not only by individual differences in achievement goals (e.g., Rawsthorne & Elliot, 1999), but also by the perceived features of the learning environment (e.g., Deci & Ryan, 2000) and task characteristics (Sansone & Thoman, 2005) as well. One of the assumptions of PBL is that it enhances students' autonomous motivation (Norman & Schmidt, 1992). Because the quality of problems is key to the success of PBL (Hung, 2006), it could be that in a PBL environment the relationship between achievement goals and autonomous motivation is partially explained by students' perception of problem quality. We therefore built a model in which we hypothesized that individual differences in achievement goals for learners in a PBL environment will affect their autonomous motivation to study and that this effect is partially explained by associated differences in their perceptions of problem quality. Figure 1 (Model A) displays our hypothesized model, outlining the proposed direct effects of achievement goals on autonomous motivation and indirect effects through their influence on perceptions of the five characteristics of high-quality problems (i.e., interest, familiarity, collaborative learning, learning objectives, and critical reasoning).

In addition, we tested two alternative models in which interest as a characteristic of high-quality problems is not proximal to the problem at hand, but instead a result of the perception of problems as familiar, as promoting collaborative learning, as resulting in the intended learning objectives, and as stimulating critical reasoning. The two alternative models are based on the notion that interest is described as one of the most important catalysts for motivation and learning in PBL (Schmidt et al., 2011) and that the quality of problems will likely increase interest (Gijselaers & Schmidt, 1990). Model B tested if there was an indirect effect of familiarity, collaborative learning, learning objectives, and critical reasoning on autonomous motivation through the interestingness of the problem. Model C tested if there was both a direct effect of familiarity, collaborative learning, learning objectives, and critical reasoning on autonomous motivation and an indirect effect of these problem characteristics through the interestingness of the problem. Figure 1 illustrates the hypothesized model and the two alternative models. We tested the models by using structural equation modeling.

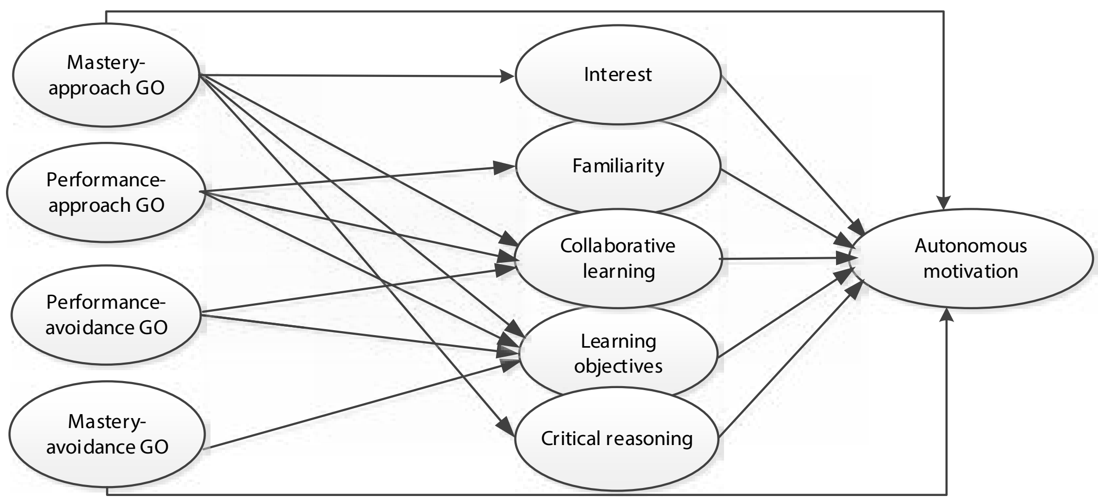
Method

Participants

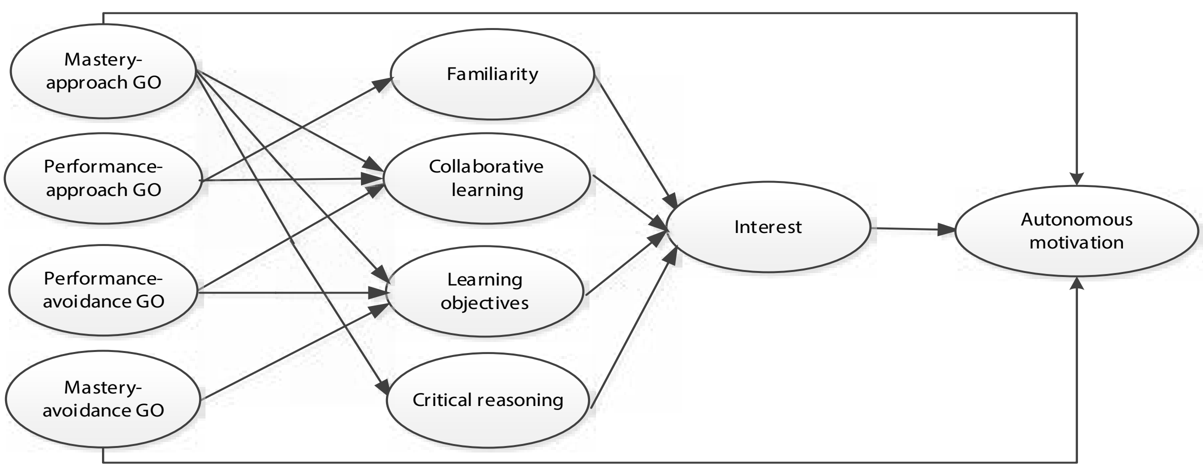
The sample consisted of all first-year psychology students from one academic year at a large Dutch university (N = 226 students). The mean age was 18.9 years (SD = 3.20). Participants consisted of 78% females; 76.1% were of Dutch origin and 23.9% of non-Dutch origin.

A common rule of thumb for determining the required sample size for structural equation modeling is a 5 to 1 ratio of sample size (N) to the number of free parameters (= d) (Bollen, 1989). However, this rule of thumb ignores the complexity of models and expectations about fit (e.g., exact or close). Therefore, MacCallum, Browne, and Sugawara (1996) proposed suggestions for how to determine the required sample size and demonstrated that the power increases with

Hypothesized model A



Alternative model B



Alternative model C

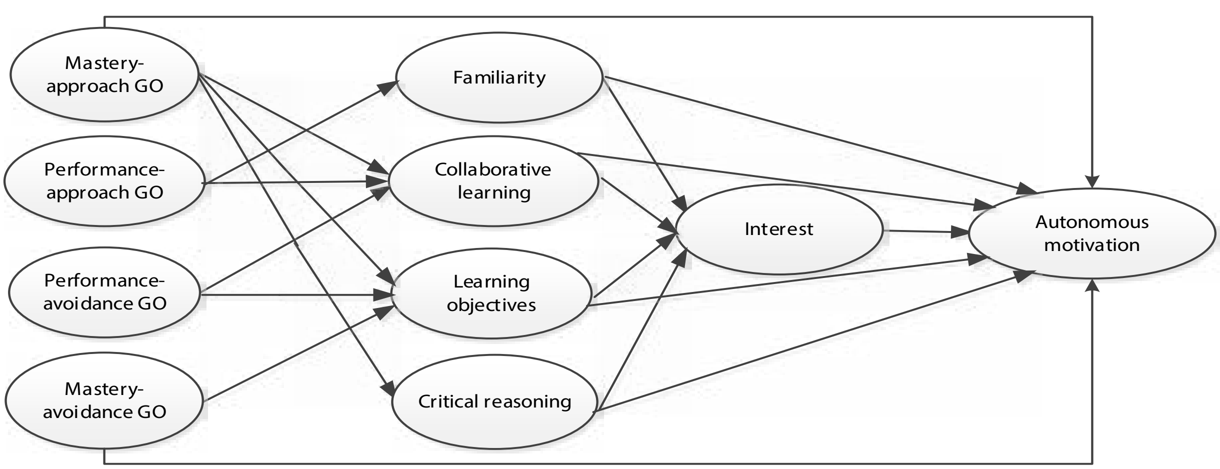


Figure 1. Hypothesized and alternative models for the effects of achievement goal orientation on autonomous motivation to study through perceived problem characteristics.
Note. All paths are expected to be positive.

a higher d. For example, in studies with N = 200 and an expected close fit, to achieve a power value above .8, d should be above 60 (p. 142).

Learning Environment

PBL is the dominant educational method at the psychology department of the university under study. Students meet two times a week in groups of 10-12 guided by a tutor (i.e., a teacher with at least a master degree assigned to the group) for the whole course. In the first meeting, students read the problem, analyze and discuss it (i.e., initial discussion phase), and formulate learning objectives. After the first meeting, students spend two to three days on self-guided study (i.e., self-guided study phase). During the second meeting students report and discuss the findings from their self-guided study (i.e., reporting phase).

Problems

Although problems in PBL are supposed to trigger students' interest, in general students differ in their interest in certain topics (Schraw & Lehman, 2001). We therefore decided to use two problems to test our models. The two problems were part of a regular five-week course (the second course of the academic year) on individual differences; eight related problems were addressed during the course. All problems were developed by PBL experts and had been used for more than five years. Two problems from this course, the fifth (Problem 1 here) and the eighth (Problem 2 here) problem, were chosen based on their ranking in the previous five years; they had been evaluated by students as the highest quality problems. Problem 1 was titled (In)stability of behavior and Problem 2 was titled The link between genes and personality (a description of the problems is available on request).

Measures

Achievement goal orientation was assessed at the start of the academic year and problem quality and autonomous motivation to study during a PBL meeting. All items use a 5-point Likert scale response format, ranging from 1 (strongly disagree) to 5 (strongly agree). Cronbach's alphas are reported in Table 2.

Trait achievement goal orientation

Students' achievement goals were assessed by means of 17 items from VandeWalle's (1997) and Baranik, Barron, and Finney's (2007) goal orientation questionnaires. Example items are: "I often look for opportunities to develop new skills and knowledge" (MAP); "I enjoy it when others are aware of how well I'm doing" (PAP); "I prefer to avoid situations where I might perform poorly" (PAV); and "I try to avoid being incompetent in performing tasks and skills" (MAV). This instrument was shown to be reliable and valid in previous studies (e.g., Creed, Fallon, & Hood, 2009).

Problem quality rating scale

The quality of the problems was assessed by means of the 32-item problem quality rating scale (Sockalingam et al., 2012). Students were asked to think about the problem that they had worked on when responding to the items. Example items: "the problem was engaging" (triggering interest); "I have worked on a similar topic as in the problem before" (familiarity); "the problem stimulated us to discuss" (collaborative learning); "the problem was clearly stated" (generating learning objectives); and "the problem stimulated me to think and reason" (stimulating critical thinking).

Academic self-regulation questionnaire

Students' autonomous motivation to study was assessed by means of seven items from the Academic Self-Regulation Questionnaire (SRQ-A; Vansteenkiste, Sierens, Soenens, Luyckx, & Lens, 2009). Item examples: "I study because this is an important life goal to me" (identified regulation) and "I study because it is fun" (intrinsic regulation). The SRQ-A has been shown to be reliable and valid (e.g., Aelterman, Vansteenkiste, & Haerens, 2019).

Procedure

All students in the first-year psychology course on individual differences rated one of the problems during a standard PBL meeting. Problem 1 was rated by 73 students and Problem 2 was rated by another 75 students, in both cases after the initial discussion phase. However, because it is known that the rating of problems likely fluctuates depending on the phase of the PBL cycle (Rotgans & Schmidt, 2011; 2014), we decided to ask the last group of students (n = 78) to rate the quality of Problem 2 after the reporting phase.

Analyses

Before testing the hypothesized models, the 32 items in the problem quality rating scale were grouped into 14 parcels, that is, combined in groups of two or three items (see Sockalingam et al., 2012). Parceling is an approved technique to correct for measurement error, while reducing the number of indicators and improving the distribution of variables and the fit of a model (e.g., Little, Rhemtulla, Gibson, & Schoemann, 2013). The 14 parcels served as indicators for the five characteristics of a problem. The five characteristics are: the extent to which the problem 1) triggers interest (parcels: triggers personal interest, stimulates engagement in self-directed learning, and captivates attention), 2) is familiar to students (parcels: is familiar with regard to the content, relates to general knowledge, and relates to subject-domain knowledge), 3) promotes collaborative learning (parcels: triggers brainstorming, triggers discussion, and encourages teamwork), 4) results in the intended learning objectives (parcels: is clear, contains elements of clue or key words, and is structured), and 5) stimulates critical reasoning (parcels: stimulates thinking, questioning, and reasoning, and encourages multiple perspectives). See Appendix A for the items and how they were grouped into parcels.

The results of a confirmatory factor analysis indicated that the five-factor model had a reasonable fit to the data, $\chi2(67) = 138.02$, $p < .001$; RMSEA = .07; SRMR = .07; TLI = .91; CFI = .94. One parcel did not contribute significantly to its underlying construct. Therefore, we removed the parcel "the extent to which the problem encourages multiple perspectives" that was used as one of the indicators of critical reasoning. The improved model fit the data better, $\chi^2(56) = 93.37$, $p = .001$; RMSEA = .05; SRMR = .06; TLI = .96; CFI = .97.

Furthermore, we checked if there were differences in the measured variables based on rating time (i.e., after the discussion or after the reporting phase) and the two problems (i.e., Problem 1 and Problem 2). Rating time did not significantly affect the extent to which a problem triggered interest, $t(224) = -0.16$, $p = .87$, was familiar to students, $t(224) = -1.08$, $p = .28$, promoted collaborative learning, $t(224) = 1.20$, $p = .23$, or stimulated critical reasoning, $t(224) = -1.35$, $p = .18$. The only significant difference was found for the generation of intended learning objectives, $t(208.57) = 5.87$, $p < .001$, indicating that students rated the extent to which a problem resulted in the intended learning objectives as higher after the reporting phase ($M = 3.59$, $SD = 0.49$) compared to after the discussion phase ($M = 3.11$, $SD = 0.71$). Likewise, no significant differences were found between Problem 1 and Problem 2 in triggering interest, $t(224) = -.67$, $p = .51$, familiarity, $t(224) = -0.02$, $p = .98$, collaborative learning, $t(177.17) = -0.30$, $p = .76$, or critical reasoning, $t(224) = 0.38$, $p = .70$. The only significant difference was found for the generation of intended learning objectives, $t(224) = 2.21$, $p =.03$, indicating that the generation of the intended learning objectives was better for Problem 2 ($M = 3.35$ $SD = 0.65$) compared to Problem 1 ($M = 3.13$, $SD = 0.69$).

For autonomous motivation, no significant difference was found in autonomous motivation between students who rated a problem after the initial discussion phase or after the reporting phase, $t(225) = 0.35$, $p = .72$, and between students who rated Problem 1 or 2, $t(225) = 1.71$, $p = .09$). Because of the significant differences in rating time (i.e., after the initial discussion or after the reporting phase) and between Problem 1 and 2 for the generation of learning objectives, we decided to include rating time and problem as control variables in our analyses.

Model Testing

We tested our hypothesized model (Model A) and two alternative models (Models B and C), by using the parcels that served as indicators of the five problem characteristics (for the parcels constructing the latent variable, standardized path coefficients were above .50, $p < .01$). The other latent constructs (achievement goals and autonomous motivation) had the individual items serving as indicators. Hypothesized Model A, indicating that the effect of achievement goals on students' autonomous motivation to study is partially explained by the five problem characteristics, provided a good fit for the data, with significant direct effects between MAP goals and autonomous motivation, between the four achievement goals and several problem characteristics, and between interest and autonomous motivation. Alternative Model B tested if the effects of familiarity, collaborative learning, learning objectives, and critical reasoning on autonomous motivation were fully mediated by the interestingness of the problem. In alternative Model C, we tested for possible direct effects of familiarity, collaborative learning, learning objectives, and critical reasoning on autonomous motivation, in addition to the mediated effects through interest. None of the path coefficients of the added direct paths was significant.

Table 1. Model comparison

Model	χ^2	df	χ^2/df ratio	TLI	CFI	RMSEA	SRMR	AIC	BIC
Null model	4369.86	741	5.90	.00	.00	.15		4447.87	4581.27
Hypothesized model A	868.96	638	1.36	.93	.94	.04	.06	1152.96	1638.68
Alternative model B (= final model)	885.28	646	1.37	.92	.93	.04	.06	1153.28	1611.64
Alternative model C	883.10	642	1.38	.92	.93	.04	.06	1159.10	1631.13

Note. N =226

The models showed a comparable fit (see Table 2 for the fit indices of the three models). To compare the three models, we made use of both the Bayesian Information Criteria (BIC) and the Akaike Information Criterion (AIC), which are both information criteria that balance parsimony and model fit (Kuha, 2004). Lower values indicate a better fit. Model A displayed the lowest AIC and the highest BIC, whereas Model C displayed the highest AIC; Model B displayed the lowest BIC and AIC comparable to that of Model A. Models that are more complex are favored by AIC, whereas BIC favors simpler models and imposes greater penalties than AIC for model complexity (Kuha, 2004). Therefore, for the sake of model parsimony (i.e., lowest BIC), we decided on Model B as our final model (see Figure 2 for the path coefficients of the final model).

Results

Descriptive statistics and intercorrelations of the variables are reported in Table 2.

Direct effects

The results of our final model indicated that both MAP and MAV goals were positively related to autonomous motivation. MAP goals were positively related to familiarity, learning objectives, and critical reasoning. MAV goals were negatively related to familiarity and learning objectives (marginally significant). PAV goals were negatively related to autonomous motivation and positively related to familiarity and learning objectives. PAP goals were not significantly related to autonomous motivation or any of the problem characteristics. The four problem characteristics were all related to interest, but this relationship was positive for familiarity, learning objectives, and critical reasoning and negative for collaborative learning. Finally, interest was positively related to autonomous motivation (see Figure 2).

Suppression effect

Inspection of the correlation matrix with the standardized regression coefficients from path analysis revealed no significant correlations of familiarity with MAV and PAV goals, while a positive relation was found in the model between PAV goals and familiarity and a negative relation between MAV goals and familiarity. No significant correlations were found between achievement goals and the generation of learning objectives, while in the model, MAP and PAV goals were positively related and MAV goals were negatively related (marginally significant) to the generation of learning objectives. This means that a suppression effect might be present. According to Conger (1974), a suppression effect occurs when adding a variable (i.e., the suppressor) to a regression equation results in an increase in the predictive validity of another variable (or set of variables). This occurs because a suppressor variable acts as a cleansing agent for the other predictors' variance, removing the variance in the predictors that is due to measurement artifacts (i.e., error variance) and thereby making the other predictors more valid (Ludlow & Klein, 2014).

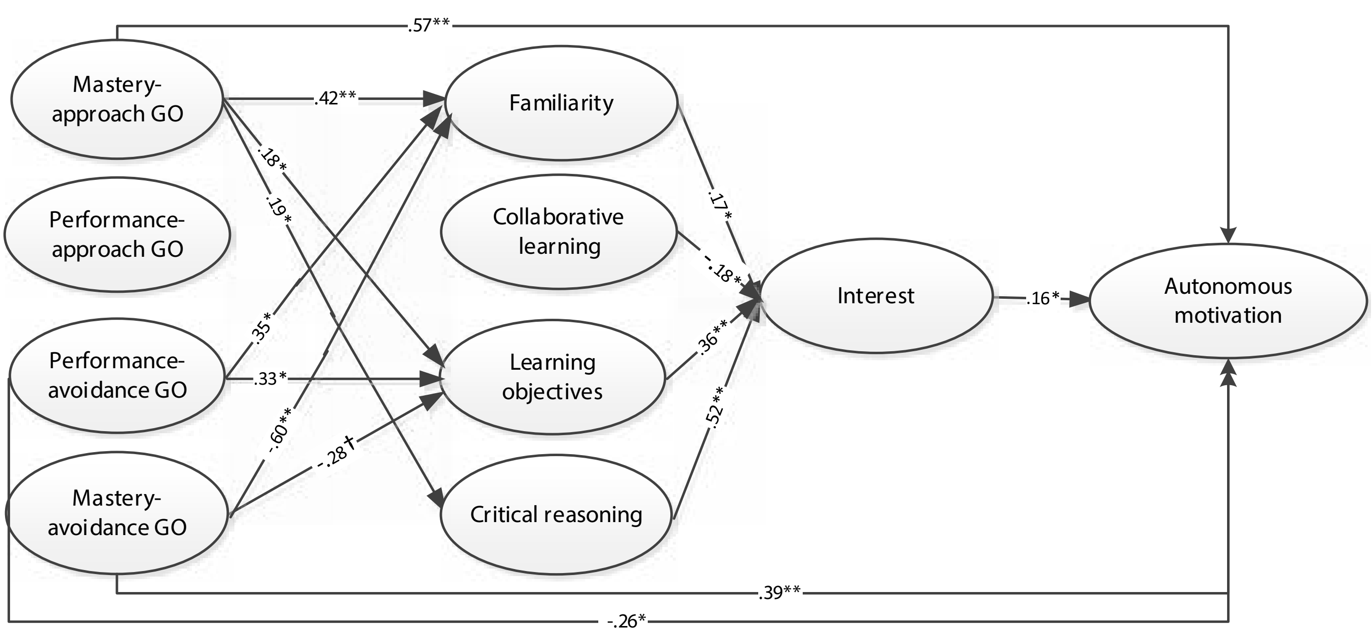


Figure 2. Final model

Note: Only (marginally) significant path coefficients are depicted. †$p < .10$. *$p < .05$. **$p < .01$.

Table 2. Descriptives and Intercorrelations of the Variables

Variables	α	M (SD)	1	2	3	4	5	6	7	8	9	10	11
1 Rating timea													
2 Problemb													
3 Mastery approach GO	.77	3.49 (0.51)	.05	-.05									
4 Performance approach GO	.83	3.11 (0.73)	.09	-.02	.14								
5 Performance avoidance GO	.82	2.86 (0.75)	-.02	-.01	-.05	.24**							
6 Mastery avoidance GO	.66	3.29 (0.62)	-.02	-.08	.16*	.28**	.51**						
7 Interest	.86	3.40 (0.70)	-.01	.05	.17*	.12	.12	-.01					
8 Familiarity	.74	2.99 (0.64)	-.07	.01	.23**	.04	.03	-.12	.40**				
9 Collaborative learning	.72	3.21 (0.63)	.08	.02	.03	-.07	.11	.08	.24**	.34**			
10 Learning objectives	.82	3.28 (0.68)	.33**	.15*	.11	.03	13	-.01	.47**	.44**	.46**		
11 Critical reasoning	.57	3.44 (0.62)	.05	-.04	.21**	13	.07	.12	.61**	.38**	.38**	.45**	
12 Autonomous motivation	.83	4.17 (0.47)	.02	-.11	.57**	.12	-.03	.22**	.20**	.11	.07	.09	.27**

Note. a0 = after the initial discussion phase; 1 = after the reporting phase. b0 = Problem 1; 1 = Problem 2. * p < .05; ** p < .01

We analyzed the suppression effect with commonality analysis (CA). CA decomposes the variance of R2 into unique and common variance of predictors (Nimon, Henson, & Gates, 2010) and in that way identifies the location and magnitude in a regression model.

Negative values of commonality coefficients indicate that a predictor exerts a suppressor effect. The results are presented in Appendix B. For both familiarity as well as learning objectives, the different negative commonality coefficients confirmed a suppressor effect for MAV goals. In the hierarchical regression analyses, the regression coefficients of MAP and PAV goals on familiarity and learning objectives were increased by entering MAV goals in the regression equation; as a result, MAP and PAV goals became more valid predictors of familiarity and learning objectives. In sum, in our model MAV goals acted as a suppressor for the effects of achievement goals on the problem characteristics of familiarity and generation of learning objectives (Appendix B shows these suppressor effects). This means that the results for MAV goals as predictors of familiarity and learning objectives are not really valid, while the other goals can be considered to be valid predictors for familiarity and learning objectives (positive for MAP and PAV goals and non-significant for PAP goals).

Indirect Effects

To test the indirect effects of achievement goals on autonomous motivation through problem characteristics, we performed bootstrapping procedures (Preacher & Hayes, 2004). All indirect effects of achievement goals on autonomous motivation through the problem characteristics were significant or marginally significant, except for MAV goals: MAP goals, estimate = .04, $p < .05$, SE = .05, 95% CI (.01, .13); PAP goals, estimate = .02, $p < .05$, SE = .03, 95% CI (.002, .06); and PAV goals, estimate = .04, $p < .10$, SE = .10, 95% CI (001, .18). Furthermore, all indirect effects of problem characteristics on autonomous motivation through interest were significant or marginally significant and positive, except for collaborative learning, which had a negative indirect effect on autonomous motivation: familiarity, estimate = .02, $p < .10$, SE = .02, 95% CI (.001, .07); collaborative learning, estimate = - .04, $p < .05$, SE = .03, 95% CI (-.12, -.01); learning objectives, estimate = .04, $p < .05$, SE = .02, 95% CI (.01, .09); and critical reasoning, estimate = .07, $p < .05$, SE =.02, 95% CI (.02,.14).

In sum, combining the results of model testing with the indirect effect tests, we can conclude that MAP, PAP, and PAV goals display an indirect effect on autonomous motivation by means of perceived problem characteristics: familiarity, the generation of learning objectives, and critical reasoning. These characteristics have an effect on the perceived interestingness of a problem, which in turn results in an increase in autonomous motivation.

Discussion

An important goal of PBL is to enhance students' motivation. However, motivational problems in PBL environments are sometimes reported (Dolmans & Schmidt, 2006). These motivational problems might be caused by individual differences (Dolmans & Gijbels, 2013). In the current study, we investigated the influence of the individual difference variable of achievement goals on students' autonomous motivation to study in a PBL context. We argued that perceived problem characteristics would play a role in this motivational process. High-quality problems are problems that are interesting, result in the intended learning objectives, are familiar, stimulate collaborative learning, and promote critical reasoning (e.g., Socklingham et al., 2012), and these problem characteristics are assumed to foster autonomous motivation (e.g., Schmidt et al., 2011). The results of our study indicated that students' achievement goals indeed influenced their perceptions of problem characteristics in PBL and in turn, these characteristics were related to students' autonomous motivation.

In contrast to our hypothesized model, it turned out that the familiarity of a problem, the stimulation of collaborative learning, the generation of learning objectives, and the promotion of critical reasoning did not display a direct relation with autonomous motivation. Instead, an indirect relationship was found through the interestingness of a problem. This finding is in line with the research by Gijselaers and Schmidt (1990), indicating that problem characteristics are the most important predictor of interest. However, although students have indicated that collaborative learning was one of the motivating elements of PBL (Wijnia et al., 2011), in our research, "collaborative learning" was negatively related to interest. An explanation could be that collaborative learning is more associated with group functioning than with the problem at hand. A highly collaborative group could enhance interest and, in turn, autonomous motivation, regardless of the task. On the other hand, collaborative learning could be perceived as an autonomously motivated as well as a controlled motivated activity, depending on the feelings of pressure due to social control (Deci & Ryan, 2000). It could be assumed that in a highly collaborative group feelings of social control are present, resulting in lower levels of self-determination and autonomous motivation. Future research should examine the conditions in which collaborative learning in PBL results in autonomous motivation.

Sansone and Thoman (2005) argued that interest might be the missing link between goals and motivation, although not all goals have the same effect on motivation. In our study, we found an indirect effect of problem characteristics, including the interest of a problem, in the relation between achievement goals and autonomous motivation, especially for students who tend to focus on self-improvement (MAP goals). Although there is already a strong relation between MAP goals and autonomous motivation, for students with MAP goals the perception of a problem as familiar and requiring critical reasoning could add something to their level of autonomous motivation through the interestingness of a problem.

In general, students with PAV and PAP goals are concerned with the pressure of others, which is likely to be associated more with controlled motivation and less with autonomous motivation (Elliot et al., 2011). However, in a PBL environment it seems that for students with PAV goals, problems that are perceived as familiar and related to the learning objectives could help them avoid a show of incompetence in their group and in that way elicit some autonomous motivation through arousing interest.

Despite the fact that most achievement goal theorists (e.g., Elliot & McGregor, 2011) have argued that MAV goals are detrimental to autonomous motivation, we found a positive direct relationship between MAV goals and autonomous motivation. For students with MAV goals, problem characteristics seem less important or even detrimental for their autonomous motivation. Students with MAV goals strive to avoid intrapersonal incompetence, which takes them cognitively away from the task itself and result in feelings of worry and anxiety (Elliot & McGregor, 2001). For them, a PBL problem does not seem to help in relieving emotional stress and as a result does not seem to serve as a starting point for learning and studying. In a PBL environment, students often mention uncertainty and insecurity about learning objectives or selecting the correct resources as one of the complicated factors of PBL (e.g., Dahlgren & Dahlgren, 2002; Wijnia et al., 2011), indicating that they are not sure when they have mastered the task. So, it might be that this is especially true for students who pursue MAV goals. Although they may be initially autonomously motivated, for them the problem in itself and the cognitive load of a less structured learning environment likely do not help them in their self-guided study and mastering the task.

Van Yperen (2006) demonstrated that almost one third of the general population favors MAV goals. In our study, 28.4% of the students rated themselves higher on MAV goals, 37% higher on MAP goals, 14.2% higher on PAP goals, and 8% rated themselves higher on PAV goals than on the other goals (12.4% of the students favored more than one goal). This finding stresses the importance of taking into account the likely differences in feelings of insecurity that result from different achievement goals.

Limitations and Future Research

For future research, it might be interesting to investigate whether providing students with pre-described learning objectives and resources and with more structure and guidance during learning activities is beneficial for all students or only for students who are anxious that they are not learning all they need to learn, that is, students with high scores on MAV goals. Providing more structure in an autonomy-supportive way helps students with their self-regulated learning skills (Sierens, Vansteenkiste, Goossens, Soenens, & Dochy, 2009).

Other suggestions for further research are based on one of the limitations of our study. We measured autonomous motivation as a general indication of motivation to study and not as an indication of self-directed study motivation for the specific topic addressed in the problem at hand. Although the perceived characteristics of a problem displayed a relation with general autonomous motivation to study, future research should incorporate more specific measures of motivation, combined with qualitative and quantitative self-directed study behavior and a subsequent assignment. This would provide us with more information on the effects of problem quality on students' learning and performance.

Conclusions

One of the core assumptions of PBL is that it enhances autonomous motivation. However, this notion is still open for debate. The results of our study suggest that enhancing autonomous motivation in PBL could be done by means of problems that are perceived as familiar, result in the intended learning objectives, and promote critical reasoning. These characteristics enhance interest in a problem, and in turn, autonomous motivation. However, the role and meaning of problems in PBL seem to differ as a function of students' achievement goals; it might even be that students with different achievement goals prefer different types of PBL problems or different arrangements of the PBL environment such as the level of structure and guidance. Therefore, both high quality problems and flexibility in guidance are essential in a PBL environment.

Implications

In almost all PBL learning environments, problem design is done by PBL experts. To assure the quality of problems, they use certain criteria, principles, or models, such as the 3C3R model by Hung (2006). However, using those principles and models as the starting point for problem development is no guarantee that students will be interested in the content of the problem or will be likely to collaborate and feel responsible for their mutual learning process. The only way to assure that students will become more autonomously motivated is by testing the problems before using them in a course or curriculum. A focus group with six to eight students who are not enrolled in that particular course, guided by a tutor or teacher, can test the problem. This will provide much information about whether the problem fulfills the requirements for high-quality problems and is likely to result in autonomous motivation for studying. Furthermore, it is always important to evaluate the learning tasks after students have worked on them, not only by means of a post-course evaluation, but again by means of a focus group with representatives of all students who were enrolled in the course. Using students' input can be a way to overcome the individual differences between students in their preferences for certain problems based on their achievement goals. Students are the only ones who can help us in designing problems that might be effective for all students. When introducing or improving a PBL curriculum, this procedure of focus groups and problem evaluation must be part of the curriculum for all problems used in the different PBL courses.

Finally, individual differences between students call for flexibility in guidance by tutors. This is true not only for the differences in achievement goals but also for other individual differences. Tutors can only be effective when they have a personal interest in students and understand the difficulties students face while engaging in PBL. Therefore, tutors should be trained not only in the PBL process but also in how to guide and help students with different needs and different goals.

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Appendix A

Problem Quality Rating Scale (including the grouping of items into parcels; from Sockalingam et al., 2012)

Problem Characteristics and parcels (in Italics)	Items
Problem characteristic 1: Triggering Interest	
1 Triggers personal interest	1a The problem is not interesting
	1b I'm curious to find the answer for this problem
2 Stimulates engagement in self-directed learning	2a The problem stimulates me to find out more information on the topic
	2b The problem stimulates me to work hard
3 Captivates attention	3a The problem is engaging
	3b The problem captivates my attention
Problem characteristic 2: Familiarity	
1 Is familiar with regard to the content	1a I was familiar with the content of the problem even before I started to work on it
	1b I have personally experienced one or more situations described in the problem
	1c I could relate to the content of the problem based on my experiences
2 Relates to general knowledge	2a The problem fits well with my prior knowledge
	2b The subject matter of the problem reflects real life issues
3 Relates to subject-domain knowledge	3a I have worked on a similar topic as in the problem before
	3b I have sufficient basic knowledge to understand the topic of the problem
Problem characteristic 3: Promoting of Collaborative Learning	
1 Triggers brainstorming	1a The problem triggered a sufficient level of brainstorming
	1b We brainstormed over the problem on what we needed to find out
2 Triggers discussion	2a Everyone in the PBL group participated in the discussion
	2b The problem stimulated us to discuss
3 Encourages group work	3a There were many different viewpoints regarding the solution
	3b Our PBL group worked efficiently
Problem characteristic 4: Generating Intended Learning Objectives	
1 Is clear	1a I was clear about what the problem required me and my PBL group to do
	1b The problem was clearly stated
2 Is containing clues or keywords	2a The problem provided sufficient clues/hints
	2b The problem contained sufficient keywords
3 Is structured	3a I was able to identify the key learning objectives from the problem
	3b I was able to come up with a satisfactory list of topics to explore based on the problem
	3c I had a logical approach to the problem
Problem characteristic 5: Stimulating Critical Reasoning	
1 Stimulates thinking, questioning, and reasoning	1a The problem triggered lots of questions in my mind
	1b I had enough ideas to respond to and understand the problem
	1c The problem stimulated me to think and reason
2 Encourages multiple perspectives*	2a The problem had more than one right answer
	2b There were many different viewpoints regarding the solution
	2c Group members had diverse opinions on the problem

*Parcel removed after factor analysis

Appendix B

	Commonality coefficients of achievement goals on familiarity		Commonality coefficients of achievement goals on learning objectives	
	Coefficient	**Total**	**Coefficient**	**Total**
Unique MAP	0.099	71%	0.027	45%
Unique PAP	0.006	4%	0.001	1%
Unique PAV	0.020	14%	0.043	72%
Unique MAV	0.071	51%	0.024	41%
MAP-PAP	0.006	5%	0.001	2%
MAP-PAV	-0.018	-13%	-0.002	-26%
MAP-MAV	-0.038	-27%	-0.012	-19%
PAP-PAV	0.005	4%	0.004	7%
PAP-MAV	-0.004	-3%	-0.001	-1%
PAV-MAV	-0.020	-14%	-0.002	-37%
MAP-PAP-PAV	-0.003	-2%	-0.001	-1%
MAP-PAP-MAV	-0.002	-1%	-0.001	-1%
MAP-PAV-MAV	0.021	15%	0.010	17%
PAP-PAV-MAV	-0.006	-4%	-0.001	-1%
MAP-PAP-PAV-MAV	0.001	1%	0.001	2%
Total	0.139	100	0.060	100

Note. MAP = mastery-approach goals, MAV = mastery-avoidance goals, PAP = performance-approach goals, PAV = performance-avoidance goals.