



MaryGrace Erickson, PURDUE UNIVERSITY, erickoso7@purdue.edu

Danielle Marks, PURDUE UNIVERSITY, marks26@purdue.edu

Elizabeth Karcher, PURDUE UNIVERSITY, ekarcher@purdue.edu

Characterizing Student Engagement with Hands-On, Problem-Based, and Lecture Activities in an Introductory College Course

ABSTRACT

This study examines the interest, motivation, and behavioral engagement of college students in an introductory course relative to three instructional formats used in the course: hands-on, problem-based laboratory stations; problem-based written case studies; and video lectures. Groups of five to seven students were assigned learning activities as treatments in a Latin Square design consisting of three experimental periods. At the beginning of selected laboratory sessions, students completed 10 minutes of the experimental activity immediately followed by a questionnaire. Students rated hands-on, problem-based laboratory stations as more challenging, novel, and attention-grabbing than they rated case studies or video lectures. Interest, intrinsic motivation, and behavioral engagement were greatest for groups completing laboratory stations followed by those completing case studies and lectures, respectively. Overall, the greater situational interest experienced during laboratory stations and case studies indicates that these activities can be leveraged to create learning environments that promote interest, engagement, and achievement.

KEYWORDS

hands-on, problem-based learning, situational interest, motivation, introductory course

INTRODUCTION

A growing number of studies show that active instructional methods may more effectively support student interest, motivation, and achievement compared with passive methods such as lecture (Blumenfeld, Kempler, & Kracjik, 2006; Freeman et al., 2014). Active instruction may be particularly impactful when implemented in introductory college courses (Hidi & Harackiewicz, 2000).

Introductory college courses, many of which are large enrollment, have traditionally been taught through lecture-based methods (Deslauriers, Schelew & Wieman, 2011). However, as active instructional methods gain acceptance in higher education, many studies have documented their benefits on interest, motivation, and performance of learners in introductory courses (Yuretich, Khan, Leckie, & Clement, 2001; Deslauriers et al., 2011; Drinkwater et al., 2014).

The recent proliferation of research on active learning, however, has left important questions unanswered (Bernstein, 2018). For example, the predominant focus on connecting instructional techniques with performance outcomes has blurred distinctions between active teaching and active

learning (Chi & Wylie, 2014). Active learning does not constitute the implementation of certain instructional practices. Rather, it denotes learners' meaningful cognitive and emotional engagement in the learning process, which instructors facilitate through specific techniques (Prince, 2004).

Still, active instruction encompasses a wide variety of educational methods (Bonwell & Eison, 1991), and there is little empirical research describing specific course activities involved in promoting active learning in the college classroom (Rowles, 2012). Research that does assess specific course activities tends to consider unitary activity types—obscuring substantial variation in instructional design, content, and implementation (Bernstein, 2018). Further, relatively little research has examined underlying cognitive and emotional processes that may mediate the effects of active learning on performance outcomes (Daniel & Poole, 2009).

Our study answers the call by Bernstein and other scholars of teaching and learning for a “second generation” of active learning research involving deeper, more specific study of defined instructional methods and the underlying processes associated with their benefits (Bernstein, 2018; Daniel & Poole, 2009; Freeman et al., 2014). We examined student interest and motivation in an introduction to animal sciences course relative to three specific instructional techniques: video lectures, case studies, and laboratory stations. These activities represent a cross-section of the course following an active learning redesign in which interactive components—case studies and laboratory stations—were added to supplement the course’s traditional lecture-based instruction. In our study, we sought to characterize students’ interest and motivation in the active and passive instructional strategies comprising the course.

THEORETICAL FRAMEWORK

Our investigation of learners’ experiences with three instructional strategies was based in a dynamic systems perspective of achievement behavior (Lewis & Granic, 2000). Within this framework, cognitive, affective, and behavioral reactions to specific learning situations reflect interactions between the immediate experience and crystallized existing schema (Ainley, 2012). More specifically, the experience of meaningful engagement that characterizes active learning (or conversely, the experience of disaffection) arises from person-environment interactions and functions within a self-organizing system of psychological processes (Izard, 2007).

Engagement

Although we acknowledge that learners’ immediate classroom experience is embedded within layers of more general contexts, the present study focuses on the microsystem associated with a discrete learning task (Bronfenbrenner, 2005). At this level, task engagement is conceptualized as the connection between person and activity on cognitive, affective, and behavioral dimensions (Frydenberg, Ainley, & Russell, 2005). In addition to measuring behavioral engagement, we further consider learners’ motivation and interest—important underlying processes that function to connect learners to tasks (Ainley, 2012).

Motivation

While engagement refers to actualized involvement with a task, motivation is the underlying psychological process activating and directing behavior. Frydenberg, Ainley, and Russell (2005, p. 1)

clarify: “motivation is about energy and direction, the reasons for behavior, why we do what we do. Engagement describes energy in action.”

Motivation exists in several forms, each varying in function (Deci & Ryan, 1985, 11-40). Intrinsically motivated behavior involves pursuing activities for their inherent satisfaction. In contrast, extrinsically motivated behavior is driven by outcomes separate from the activity (Ryan & Deci, 2000). In their influential self-determination theory, Ryan and Deci further set forth several types of extrinsic motivation based on the individual’s internalization of the activity’s value. Extrinsic motivation, according to the authors, can exist as external regulation, introjected regulation, identified regulation, and integrated regulation (Ryan & Deci, 2000). In education settings, important functional differences exist along Deci and Ryan’s motivation continuum. Students with greater levels of internalized, self-determined motivation (e.g. intrinsic motivation, identified regulation) tend to exhibit enhanced performance, persistence, and creativity (Ryan & Deci, 2000), greater satisfaction, more positive emotions, and more enjoyment in their academic work (Vallerand, Blais, Brière, & Pelletier, 1989). Conversely, amotivation in the classroom (behavior disconnected from values and interests) is associated with poor academic performance and reduced well-being (Ryan & Deci, 2000).

At the course level, several studies have shown that students experience greater intrinsic motivation when they perceive instructors as supportive of students actively engaging in the learning process (Black & Deci, 2000; Guay, Boggiano, & Vallerand, 2001). Other work has centered on the motivational effects of specific active learning strategies, particularly in higher education settings. Blumenfeld, Kempler, and Kracjik (2006) report that college classrooms using active learning principles such as inquiry, authenticity, and collaboration are more likely to be intrinsically motivating to students. Jeno, Raaheim, Kristensen, Kristensen, Hole, Haugland, and Mæland (2017) showed that team-based learning increased intrinsic motivation and identified regulation and decreased amotivation compared with lecture-based instruction for college students. Similarly, Serrano-Cámara, Paredes-Velasco, Alcover, & Velazquez-Iturbide (2014) reported higher levels of intrinsic motivation for college freshmen involved in collaborative learning activities compared with lecture.

Interest

Interest, like motivation, is associated with learner engagement. Interest is a basic emotion that motivates learning and exploration (Silvia, 2008). It includes both cognitive and affective components (Hidi, Renninger, & Krapp, 2004; Renninger & Hidi, 2011). In educational settings, interest precipitates academic engagement and achievement, promoting attention, persistence, and effort (Ainley, Hidi, & Berndorff, 2002; Hidi, 1990; Hidi & Renninger, 2006). Like motivation, interest develops through internalization processes. Consequently, both intrinsic and extrinsic factors serve important functions in stimulating and holding interest (Hidi & Renninger, 2006).

Interest research has followed a similar but separate trajectory to motivation research. Interest is generally conceptualized as existing in two forms: situational and individual (Hidi & Renninger, 2006). Situational interest is the focused, attentive psychological state experienced in the moment and triggered by environmental stimuli (Krapp, Hidi, & Renninger, 1992). In contrast, individual interest refers to a relatively stable trait-like predisposition to reengage with a particular content and signifies deepening knowledge and value of the subject area (Renninger, 2000). Our study focused on situational interest processes associated with specific learning tasks.

Situational interest can be triggered by features of the learning environment or task, or it can represent actualized individual interest in a particular content area (Hidi & Renninger, 2006). Anecdotally, educators report using a wide variety of tactics to stimulate and hold interest. Text- and task-based factors such as coherence (Schraw, Bruning, & Svoboda, 1995), relevance (Schraw & Dennison, 1994), and vividness (Kintsch, 1980) tend to be associated with greater situational interest. Hidi and Renninger (2006) suggest that people are more interested in tasks perceived as meaningful. The study of interest may be particularly relevant in active learning contexts (Rotgans & Schmidt, 2011). There is evidence that problem-based, collaborative, and hands-on approaches enhance interest (Gokhale, 1995; Holstermann, Grube, & Bögeholz, 2009; Rotgans & Schmidt, 2011). However, situational interest has predominantly been studied under controlled laboratory settings. The actualization of interest in the context of real learning activities or within classroom settings is poorly understood (Bergin, 1999; Alexander & Jetton, 2000; Rotgans & Schmidt, 2011).

OUR STUDY

We hypothesized that the quality of students' experiences would differ for different instructional formats, resulting in differing manifestations of situational interest, intrinsic motivation, and behavioral engagement (Krapp, 2005). For experimental treatments, we selected three learning activities representing a cross-section of both the passive and active methods used in the course. In addition to lecture instruction, the course includes activities using problem-based and hands-on learning. Problem-based learning is an active instructional model in which learners work in groups to research solutions for an authentic problem (Jonassen & Hung, 2008). In our course, problem-based learning is implemented with small group lecture-based cases (Barrows, 1986). In course laboratories, case-based scenarios are extended to include hands-on learning components. We define hands-on activities as those that allow students to interact with real physical objects related to the content to discover information or perform tasks.

PURPOSE

The purpose of our study was to examine interest, motivation, and engagement of students involved in passive and active instructional techniques during an introductory animal science course. Our study was guided by the following two questions:

1. ***How do video lecture, laboratory station, and case study activities affect students' situational motivation and situational interest?***
2. ***How do video lecture, laboratory station, and case study activities affect students' behavioral engagement?***

METHOD

Participants and context

This study involved a convenience sample of 178 students enrolled in an introduction to animal agriculture course during the fall 2018 semester. This 16-week course consists of twice-weekly 50-minute lectures and a weekly 110-minute laboratory session. Laboratories were divided into five sections of 35 to 45 students each. The course is required for the animal sciences major and is primarily composed of females (86.52 percent, $n = 154$). More students were classified as first-year (42.70 percent, $n = 76$) than for any other single year. The majority of students had no or minimal experience

with livestock species, with 87.79 percent of the class reporting less than 20 hours experience in the last five years ($n = 151$). Historically, the course was taught using primarily traditional, passive learning methods. In the fall 2017 semester, the course was remodeled to reflect a more active, learner-centered approach (Erickson, Guberman, Zhu, & Karcher, 2019). Active instructional updates included changes to both course lectures and laboratories. For the lecture portion of the course, clicker questions, think-pair-share activities, and case studies comprised the active learning update. Course laboratories were revised to include stations with hands-on activities. These active learning techniques were added to support departmental goals to increase student interest in the subject and improve performance and retention.

Study design

All procedures for this study were approved by the university's institutional review board. This quantitative experiment assessed three types of learning activities. Table 1 describes the standard procedures for course activities used as treatments.

Table 1. Summary of instructional formats used as experimental treatments

TREATMENT	DESCRIPTION
Video lecture	Learners watch lecture slides and listen to audio voiceover of the instructor describing concepts. Learners may or may not take notes. Minimal interactions occur between group members.
Problem-based case study	Using a packet of reference materials, learners work through a realistic written case study. Group members discuss the problem and provide verbal evidence of their viewpoints. The group must agree on a consensus and justify their choices in brief written responses (approximately 3–5 sentences) to case scenario prompts. Course instructors are available to answer questions but provide minimal guidance throughout the process.
Problem-based, hands-on laboratory station	Using a packet of reference materials, learners work through a realistic written case. In addition to discussing the problem in their group, learners must discover evidence by observing or completing tasks with physical objects related to the problem scenario. The group must agree on a consensus and justify their choices in brief written responses (approximately 3–5 sentences) to case scenario prompts. Course instructors are available to answer questions but provide minimal guidance throughout the process.

We completed the experiment during three of the course's weekly laboratory sessions, during weeks seven, nine, and ten of the semester. Each experiment day was considered an experimental period. For each period, the course's five laboratory sections were each split into three treatment groups and each assigned two groups of five to seven students. During each laboratory, students completed the assigned experimental activity and survey before moving on to normal course activities. One experimental period therefore consisted of five repetitions conducted over an experiment day with students from each of the five course laboratory sections.

Randomly assigned treatments were assigned and rotated in a Latin square arrangement, with experimental activities repeated five times for each period (Table 2). In each experimental period, content and learning objectives were standardized across the video lecture, laboratory station, and case

study activities. In addition, content was delivered using the same text and pictures across activities, provided to students either through lecture slides or as supporting materials for case-based activities. Content and learning objectives were varied for each repetition to prevent prior exposure to the material from confounding results and to control for interactions between content and instructional format. However, for each experimental period, text and pictures were nearly identical between video lecture, laboratory station, and case study activities to prevent factors other than the delivery format from influencing students' situational experience (Rotgans & Schmidt, 2011).

For each experimental period, we recorded all groups of students on video, and collected completed handouts. We used the artifacts and recorded video to confirm that students engaged with each activity in the manner intended: hands-on learning or problem-based learning.

Table 2. Latin square treatment arrangement

GROUP #	PERIOD 1 WEEK 7	PERIOD 2 WEEK 9	PERIOD 3 WEEK 10
1	Lecture	Case study	Lab station
2	Lab station	Lecture	Case study
3	Case study	Lab station	Lecture
4	Lecture	Case study	Lab station
5	Lab station	Lecture	Case study
6	Case study	Lab station	Lecture

Instrumentation

We chose self-report measures to quantify situational interest, situational motivation, and individual interest. Although motivational variables can be measured through both self-report and behavioral observation, self-report measures can provide more information about the nature and extent of interest and motivation (Renninger, 2000). Self-report questionnaires are appropriate for studies with large samples of participants or involving populations where the phenomena in question have not been well documented (Fulmer & Frijters, 2009; Renninger, 2000). We constructed a questionnaire based upon previously validated instruments for measuring situational interest, situational motivation, and individual interest.

Situational interest was measured using the situational interest scale developed by Chen, Darst, and Pangrazi (1999). Compared with the situational interest scale developed by Linnenbrink-Garcia, Durik, Conley, Barron, Tauer, Karabenick, and Harackiewicz (2010) to measure interest at the course level, Chen, Darst, and Pangrazi's (1999) is more suitable to learning activities and tasks. In addition, the situational interest scale is grounded in self-determination theory and addresses both the affective and task-value components of situational interest, making it compatible with our working conceptualizations of interest and motivation (Chen et al., 1999; Renninger & Hidi, 2011). Although developed for physical education, this scale has since been successfully adapted for a diverse range of educational experiences (Dan & Lan, 2010; Roberts, 2015). Cronbach's alpha coefficient for our sample was 0.96, indicating excellent internal consistency of the measure (Tavakol & Dennick, 2011).

We measured situational motivation using Guay, Vallerand, and Blanchard's (2000) situational motivation scale. To our knowledge, the situational motivation scale is the only existing scale for the multidimensional assessment of intrinsic and extrinsic motivation at the situational level (Guay et al.,

2000). The instrument's sensitivity made it well suited to profile motivation for the closely related experiences we chose as treatments. The situational motivation scale is rooted in self-determination theory and has been widely used as a measure of academic motivation in college undergraduates (Kirby, Byra, Readdy, & Wallhead, 2015; Yu, Levesque-Bristol, & Maeda, 2018). Cronbach's alpha coefficient for the intrinsic motivation, identified regulation, external regulation, amotivation subscales were 0.99, 0.87, 0.85, and 0.88 respectively. This indicates good reliability of the measure with our data set (Tavakol & Dennick, 2011).

We assigned completion grades to students involved in experimental activities rather than effort- or standards-based grades. This choice was made (1) to reflect the natural structure of the activities within our course and (2) to prevent external pressures from interfering with our study of motivation. In some studies, external rewards have been shown to undermine intrinsic motivation (see Hewett & Conway, 2016). We decided that completion grades would prevent this undermining effect from interfering substantially with our study of intrinsic motivation.

Experimental procedure

Course instructors and teaching assistants used the following procedure in each laboratory section across experimental periods. First, we divided students in each of the course's five laboratory sections into groups of five to seven students ($n = 30$) and seated students in each group around a table. Groups and table location remained constant across experimental periods. Then, we informed students that they would complete an activity and a survey and that their responses would not affect their grade. Next, we distributed instructional materials to each table. Finally, we told students they would have 10 minutes to complete the activity and asked everyone to begin. For each experimental period, students completed the activity within 7 to 10 minutes. Immediately following activity completion, we administered the survey via Qualtrics (Qualtrics, Inc., Provo, UT). Students used laptops, tablets, or mobile phones to complete questionnaires, which required students to complete each item before advancing. In each experimental period, all students in attendance completed the activity and questionnaire. Of the students enrolled in the course, survey response rates were 97.2 percent, 93.8 percent, and 92.3 percent for the first, second, and third experimental periods, respectively.

Behavioral observation

We measured behavioral engagement through observation. During each experimental period, we recorded video of students completing assigned activities. Three trained observers rated student engagement in video recordings using the behavioral engagement related to instruction protocol (Lane & Harris, 2015). Observers viewed 10-minute video segments beginning when students were presented with instructional materials and instructed to begin, recording student ratings at minutes 1:00, 3:00, and 5:00.

Observers were trained with sections of footage taken during the experimental day but not used for the project. During an initial training period, observer-trainees rated 15 minutes of video alongside a trained observer, discussing discrepancies after each rating. Next, observer-trainees rated 15 minutes of video independently, generating ratings for six time points. Each observer-trainee's ratings for this independent rating period were compared with those of a trained observer. If a Cohen's kappa statistic greater than 0.70 was achieved, observers were considered adequately trained. If observer-trainees failed to rate in agreement enough to generate Cohen's kappa values greater than 0.70, they discussed

discrepancies with the trained observer and entered remedial 15-minute independent rating sessions until adequate interrater reliability was established. Unweighted Cohen's kappa values exceeding 0.70 indicate substantial observer agreement (Landis & Koch, 1977). Cohen's kappa statistic is frequently used to test interrater reliability and is more robust than percent agreement because it accounts for chance agreement (McHugh, 2012).

Statistical analyses

We completed all data analyses using SAS software (SAS Institute Inc., Cary, NC). Prior to analysis, we used the UNIVARIATE procedure to perform Shapiro-Wilk's normality test. For objective 1, we compared least squares means of treatment effects using SAS's MIXED procedure, including experimental period as a repeated effect with SUBJECT=group. We selected compound symmetry as the covariance structure on the basis of best fit based on Schwarz's Bayesian information criteria. For objective 2, we accounted for non-normality and bounded support of behavioral engagement data by fitting a generalized linear mixed model using SAS's PROC GLIMMIX. Experimental group was included as a random effect. We tested fixed video observer and period effects and excluded them as non-significant. No data were excluded.

RESULTS

Table 3 presents least squares means for animal science introductory course students across three experimental periods at weeks 7, 9, and 10 of the 16-week semester ($n=501$) for situational interest scale subscales and the overall scale average (Likert scale: 5 = strongly agree, 1 = strongly disagree). No significant difference ($p > 0.05$) was observed between treatments for values with the same superscript. Situational interest was highest for students completing laboratory stations, followed by case studies and video lectures, respectively. Students perceived laboratory stations as more challenging, novel, and attention-grabbing than video lectures and case studies. Students rated laboratory stations and case studies higher than video lectures in terms of instant enjoyment and exploration intention.

Table 3. Profile of situational interest during experimental activities

SITUATIONAL INTEREST SCALE	VIDEO LECTURE	LAB STATION	CASE STUDY
Exploration intention	3.38 ^a	3.76 ^b	3.71 ^b
Instant enjoyment	2.71 ^a	3.61 ^b	3.44 ^b
Novelty	2.50 ^a	3.38 ^b	2.80 ^c
Attention demand	2.74 ^a	3.81 ^b	3.51 ^c
Challenge	1.82 ^a	2.45 ^b	2.15 ^c
Total interest	2.60 ^a	3.58 ^b	3.27 ^c
Situational interest	2.63 ^a	3.43^b	3.15^c

Table 4. Profile of situational motivation during experimental activities

SITUATIONAL MOTIVATION SCALE	VIDEO LECTURE	LAB STATION	CASE STUDY
Intrinsic motivation	3.38 ^a	4.40 ^b	4.07 ^c
Identified regulation	4.12 ^a	4.65 ^b	4.45 ^b
External regulation	4.76 ^a	4.61 ^a	4.62 ^a
Amotivation	3.19 ^a	2.91 ^b	2.87 ^b

Table 4 presents the least squares means for animal sciences introductory course students across three experimental periods at weeks 7, 9, and 10 of the 16-week semester ($n=501$) for the situational motivation scale subscales (Anchored scale: 1 = corresponds not at all, 7 = corresponds exactly). No significant difference ($p > 0.05$) was observed between treatments for values with the same superscript. Situational intrinsic motivation was greatest for students completing laboratory stations followed by case studies and lectures, respectively. Students perceived greater identified regulation with laboratory stations compared with video lectures and case studies. We observed no differences in external regulation between instructional formats. However, students' amotivation was higher following video lectures compared with laboratory stations and case studies.

Table 5. Behavioral engagement across experimental activities

	VIDEO LECTURE	LAB STATION	CASE STUDY
% engaged	63.12 ^a	81.29 ^b	73.17 ^b

Table 5 shows the least squares means for animal sciences introductory course student groups across three experimental periods at weeks 7, 9, and 10 of the 16-week semester ($n=501$) for percent engaged students based on the behavioral engagement related to instruction (BERI) protocol. No significant difference ($p > 0.05$) was observed between values with the same superscript. Behavioral engagement was significantly higher for groups completing laboratory station activities. No difference was observed between behavioral engagement with video lecture and case study activities.

DISCUSSION

Our objective was to investigate situational interest, motivation, and engagement in students relative to different instructional formats used in an introductory course. We involved students in video lecture activities representing passive learning, and case study and laboratory station activities with problem-based components. In addition to being problem-based, laboratory stations involved students in hands-on learning. We hypothesized that the quality of students' experiences would differ for each activity, resulting in differing manifestations of situational interest, intrinsic motivation, and behavioral engagement (Krapp, 2005).

We found significant differences between activities' effects on situational interest, situational intrinsic motivation, and behavioral engagement. In our study, students involved in problem-based, hands-on laboratory stations experienced the most situational interest, situational intrinsic motivation, and behavioral engagement, followed by students engaged in problem-based case studies and lecture-based treatment groups. Our findings add to a growing body of literature documenting the benefits of problem-based and hands-on activities (Barrows, 1986; Dhanapal & Shan, 2014; McDonald, Reynolds, Bixley, & Spronken-Smith, 2017). Many have shown that students tend to prefer problem-based learning and hands-on activities to lecture-based instruction, finding these approaches more enjoyable, interesting, and motivating (Abrahams, 2009; Hodson, 1990; Middleton, 1995).

In contrast, we found external regulation and identified regulation were similar across treatments. Students reported relatively higher levels of each type of extrinsic motivation than they did those of intrinsic motivation. Extrinsic incentives that may be responsible include the low-point-value grade we offered students for completing assigned activities and value-based incentives (such as avoidance of guilt, social image concerns) (Underhill, 2016). Although both intrinsic and extrinsic

rewards function within rich networks of motivators determining achievement behavior, the role of extrinsic rewards remains controversial in education (Hidi & Renninger, 2006). While extrinsic motivation can serve important roles in facilitating internalization processes—particularly when individuals have low initial interest in tasks (Hidi & Harackiewicz, 2000; Zimmerman, 1985)—extrinsic rewards can also undermine intrinsic motivation (Hewett & Conway, 2016). More research investigating the complex interactions between types of motivation is needed to understand internalization of regulation for different types of academic activities (Hidi & Harackiewicz, 2000; Rigby, Deci, Patrick, & Ryan, 1992).

As research on active learning instruction advances beyond dichotomous consideration of active and passive learning environments, considering specific types of active learning and their defining characteristics is becoming increasingly salient. As Holstermann, Grube, and Bögeholz (2009) point out, problem-based and hands-on learning can be implemented through a variety of methods—each with different motivational implications. For example, Barrows (1986) claims that problem-based methods allowing more free inquiry or incorporation of prior knowledge may more effectively support student motivation than more structured methods like the written problem-based case studies employed in our study. Problem-based activities can also vary in the means used to present the problem. Although text-based resources have traditionally figured prominently in problem-based learning, activities including hands-on components appear to be increasing in popularity (Barrows, 2000; Hmelo-Silver, 2004; Linn & Slotta, 2006). Problem-based activities requiring students to consult various resources may support learner motivation and interest by enhancing students' senses of inquiry, excitement, enjoyment, and authenticity (Bergin, 1999; Hmelo-Silver, Duncan, & Chinn, 2007).

For decades, hands-on learning through laboratories has been foundational to promoting interest and motivation in K-16 science education (Hofstein & Lunetta, 2003). Tying content knowledge to physical experience, Kontra, Lyons, Fischer, and Beilock (2015) argue, activates students' sensorimotor brain systems and enhances perceived meaningfulness. Importantly, factors within learners may affect their reception of these techniques. Zacharia, Loizou, and Papaevripidou (2012) propose that hands-on, physical learning experiences may be most influential in early stages of learning when students often must correct prior misconceptions. In contrast, Holstermann, Grube, and Bögeholz (2009) reported no significant differences in interest between learners with and without prior experience related to hands-on learning activities. Haigh and Gold (1993) explain that in some cases, activities with both hands-on and problem-based learning components may be overwhelming to students, reducing their perception of competence and subsequent motivation. Our study did not assess students' prior experience or attitudes toward activities, which may be important topics for future research.

Students' instructional preferences may also be influenced by their personal motivational traits and orientations. Kempa and Diaz (1990) reported that students categorized as "conscientious" tended to prefer more formal learning environments, whereas other students tended to be more open to learning through problem-based and hands-on activities. Our study did not address the motivational implications of personality differences in students. Factors such as preexisting individual interest, self-efficacy, and achievement goals may have influenced learners' experience in our study and are an important topic for future research.

In our case study and laboratory station activities, group dynamics may have also affected students' experiences. Savin-Badin (2000) lists over-dominant group members, an incentive to freeload,

and personality clashes as among possible disturbances affecting problem-based activity function (Savin-Badin, 2000). Although our study assumed these differences were homogeneous across treatments, it is possible that different instructional formats may alter the magnitude of realized group-related effects. Although group dynamics can have negative effects, they also play an important role in learning activities' effectiveness (Barrows, 1986; Rotgans & Schmidt, 2012; Webb & Engar, 2016). Alvarez-Bell, Wirtz, and Bian (2017) showed that both involvement in group learning and feelings about group learning predicted engagement in active learning settings.

Activities like the laboratory stations and case studies we tested—which emphasize collaboration and provide students more choice—may also more effectively support learner motivation by promoting autonomy and relatedness. Fulfillment of basic psychological needs for competence, autonomy, and relatedness has been demonstrated to support intrinsic motivation (LaGuardia, Ryan, Couchman, & Deci, 2000). According to Krapp (2005), basic psychological needs fulfillment may also contribute to the development of interest. Krapp bases this conclusion on a study by Wild (2000) which used hierarchical linear modeling to demonstrate that basic-psychological-needs-related experiences significantly predicted individuals' development of interest-related motivational orientations relative to a vocational education program. From a qualitative perspective, in Lewalter, Krapp, Schreyer, and Wild's (1998) study of content-specific interest relative to a vocational education program, participants spontaneously mentioned basic psychological needs fulfillment when asked to explain the initiation and maintenance of their interest in the subject.

Finally, our nomothetic approach captured only a peripheral view of student engagement with specific activities during a short time frame—bracketing out the social, historical, and cultural components reflexively influencing engaged participation (Azevedo, 2013). Although our student sample was diverse in many dimensions, it was a convenience sample of students enrolled in the introductory animal science course. Results may not be generalizable beyond this or similar populations. Future studies integrating insights from both psychology and sociocultural learning theories may provide more insight on the psychological processes and structural features underlying engagement and achievement within specific communities of practice. Similarly, long-term studies from a developmental perspective may capture a fuller view of engagement than our study of situational factors during a single semester (Chen et al., 1999).

CONCLUSION

Our research considered students' experiences with three educational activities in an introductory course from multiple perspectives—integrating third-party observation of behavioral engagement with self-report measurement of situational interest and motivation. Participants in our study engaged most deeply and experienced the greatest interest and intrinsic motivation with hands-on, problem-based laboratory stations, followed by problem-based case studies and video lecture activities. Our results show that while both intrinsic and extrinsic sources contributed to students' motivation to engage with activities, problem-based case studies and hands-on, problem-based laboratory stations were associated with greater internalization of motivation. Case studies and laboratory stations were rated more enjoyable, novel, challenging, and attention-demanding than video lectures. The greater overall situational interest experienced during laboratory stations and case studies indicates that educators and instructional designers can leverage these and similar activities to create learning environments that promote interest, intrinsic motivation, and engagement.

MaryGrace Erickson is a doctoral student in the Department of Animal and Dairy Sciences at the University of Wisconsin–Madison (USA). While writing this article, she was the laboratory coordinator for Purdue University's Introduction to Animal Agriculture course.

Danielle Marks is a Master of Science student in the Department of Animal Sciences at Purdue University in West Lafayette, IN (USA). She has served as both lecture and laboratory coordinator for Purdue University's Introduction to Animal Agriculture course.

Elizabeth Karcher is an Assistant Professor and the Undergraduate Programs Coordinator in the Department of Animal Sciences at Purdue University in West Lafayette, IN (USA). She is the instructor for Purdue University's Introduction to Animal Agriculture course.

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