Journal of Cognitive Education and Psychology
Volume 15, Number 1, 2016

An Exploratory Pilot Study of Student Learning Experiences in Engineering Technology Courses Designed to Promote Creativity

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We report on the findings from an exploratory pilot study using the experience-sampling method (ESM) and interviews to examine learning in two undergraduate engineering technology courses designed to promote creativity. Results of the ESM analysis showed that students' positive experience decreased slightly in the first course and increased slightly in the latter course. Surprisingly, both instructors' presence caused students to report lower levels of willingness to express a creative idea and feel like other students were really listening. Interviews revealed student perceptions about the importance of creativity as essential to the engineering industry and beliefs about being creative in the classroom during the stages of the design process, which relies heavily on group work. Discussion builds on these themes for facilitating creative classrooms emphasizing work with peers as an integral part of curricular and instructional design.

Keywords: creativity; assessment; instruction; engineering technology

Creativity, or the ability to produce new, useful ideas and products that are high in quality (Sternberg, Jarvin, & Grigorenko, 2009), has been an understudied construct in engineering education as well as other science, technology, engineering, and math (STEM) disciplines (Reisman, 2010), in which creative thinking and problem solving are needed to design new equipment, systems, and facilities (Dhillon, 2006).[1] In this article,

http://dx.doi.org/10.1891/1945-8959.15.1.55

we report on an exploratory pilot study that used the experience sampling method (ESM) coupled with group interviews to gain insight into students' learning experiences in two engineering technology courses designed to promote creativity. Eighteen students completed 10 weeks of surveys based on the 500 Family Study (Schneider & Waite, 2005) and the Sloan Study of Youth and Social Development (Hektner, Schmidt, & Csikszentmihalyi, 2007), generating 192 survey responses (Table 1). The survey was administered on iPod Touches (Figure 1) while students were engaged in projects designed to enhance their capacity to be creative in the context of their coursework (Table 2). Eight of those students also participated in group-based interviews designed to deepen and extend insight into their perceptions of being creative.

In the following sections, we provide a framework that links emotional, cognitive, and social components of learning in the classroom for studying undergraduate engineering students' course experiences. We then describe the construction and administration of the survey in the two engineering technology courses, in addition to the group interviews.

FIGURE 1. Screenshot of ESM survey item "How creative do you feel?" on iPod touch device.

Finally, we report the results of students' experiences in the course and provide a discussion of the outcomes and their implications for designing engineering technology courses to foster student creativity.

BACKGROUND: CREATIVITY AND LEARNING IN HIGHER EDUCATION

Creativity and academic potential can reinforce each other (A. J. Cropley, 2006), but this requires that students build a strong orientation toward learning (Standards for Success, 2003). Creativity is a higher order thinking skill demanding considerable depth of content knowledge as well as novel or original thinking that is also useful or practical and is necessary for success in engineering classrooms across universities (D. H. Cropley & Cropley, 2000; Liu & Schonwetter, 2004; Mann, Mann, Strutz, Duncan, & Yoon, 2011; Sternberg et al., 2009). Assessing learning in the higher education classroom designed to promote creativity is a complex process. In this article, we assert that learning in such contexts involves the salient emotional and social aspects that often get ignored in practice. The process of being creative rests on a learner's capacity to derive, convey, and revise new ideas in the social setting of a classroom. This can be especially true for engineering technology classrooms that involve group projects.

Engineering curricula in higher education tend to rely on lectures, assignments, and exams at the expense of solving real-world problems that have open-ended solutions deemed essential to the applied field of engineering (Dhillon, 2006; Felder, 1988).[2] Although lecture and memorization are necessary, they often reinforce passivity in students, which in turn can be linked to deactivated emotions and low arousal (e.g., boredom) found to hinder creativity and learning in classrooms (Hunter & Csikszentmihalyi, 2003). Instructional concerns in engineering courses include students acting passively in class, lacking the ability to sustain a deep intellectual focus on engineering problems, and picking engineering solutions too quickly before they have explored the problem (Felder, 1988). Cultivating creativity in classrooms can involve developing skills in problem formulation (Silver, 1997), avoiding premature closure of ideas (Dowd, 1989), and exploring associative paths of thought (Goel, 1997). Therefore, giving engineering students more opportunities to be creative can be a way to address this lack of student engagement. Emotional and social components of learning in classrooms designed to promote creativity are examined in the next sections.

EMOTIONAL ASPECTS OF LEARNING RELATED TO CREATIVITY

Negative emotions such as boredom and cognitive states such as low engagement are thought to be associated with maladaptive learning patterns (Dweck, 1986) that also may theoretically hamper learning in the classroom designed to promote creativity. The learning process has an emotional component that may be equally important as cognitive states such as high cognitive engagement but is less clear (Kaufman & Beghetto, 2009). For example, creativity has been associated with positive emotions and cognitive states, which can be indicators of academic engagement (cf. Amabile, 1996; Csikszentmihalyi, Rathunde, & Whalen, 1993). For instance, mild positive affect has been associated with idea exploration, cognitive flexibility, and even task performance (Isen, 2008). In addition, the feeling of enjoyment and cognitive challenge can sustain interest and intrinsic motivation while solving problems creatively (Csikszentmihalyi, 1996). In some psychological studies, negative mood has no effect on creativity, whereas other research indicates that negative mood can support creative performance (Amabile, 1996; Kaufman & Beghetto, 2009). Negative moods have been described as playing a role in triggering effortful cognitive strategies, but they can also impede and therefore slow down analytic strategies (Paulus & Nijstad, 2003). As a result, negative moods have the capacity to destabilize the feeling of psychological safety in work groups (Edmondson, 1999), which can impact students working in small groups in university courses such as engineering technology. Indeed, negative emotions such as worrying and shame (Turner & Husman, 2008) might impede a student's creative self-efficacy (Beghetto & Baxter, 2012; Beghetto, Kaufman, & Baxter, 2011) and even academic performance (Mega, Ronconi, & De Beni, 2013).

SOCIAL COMPONENTS OF LEARNING RELATED TO CREATIVITY

The aforementioned research on the role emotion plays in learning is important for the learner in the context of individual work as well as group work (e.g., Isaksen, Dorval, & Treffinger, 2011; Puccio, Mance, & Murdock, 2011). A commonly held understanding is that the creative process relies, in part, from withholding premature judgment and negative feelings when communicating (Isaksen et al., 2011). This is an important skill for students to learn and practice when discussing the relative merits of ideas. For example, open-ended instructional prompts that focus on deriving many ideas and not "killing" or judging the ideas of others are thought to help keep student conversation naturalistic and freewheeling (Sawyer, 2007). In turn, group conditions for psychological safety (Edmondson, 1999) are more likely to emerge and reinforce the cycle of deferring judgment and discussing new ideas. Judgment and emotional conflict can reinforce task-related boredom and/or anxiety (Csikszentmihalyi, 1996) mentioned earlier. In turn, these behaviors can present social barriers to the learning process in classrooms designed to promote creativity. And if these behaviors are part of evaluation (as in "evaluation apprehension"; see Rosenberg, 2009), this can further impede student creativity during key points of project development.

Although higher education programs typically rely on course evaluations to assess student perceptions of their learning experience (Spooren, Brockx, & Mortelmans, 2013), such retrospective snapshots of student perceptions can gloss over important in-the-moment experiences that represent learning in the classroom. To that end, studies have used various methods to collect data on students' cognitive, affective, and behavioral engagement in real time. For example, Hektner et al. (2007) used the ESM to gather multiple, self-reported responses concerning positive and negative affect and cognitive challenge, risk taking, and self-efficacy in adolescents' classroom experiences (cf. Hunter & Csikszentmihalyi, 2003).

PRESENT STUDY

ESM can provide feedback to instructors and can also be a means for assessing new pedagogical techniques in the classroom. To pilot this endeavor, this study uses ESM and interviews to collect data on students' learning experiences across two courses designed to promote creativity (one course's faculty member attended creativity workshops and the other course's faculty member did not attend the creativity workshops). The research questions were as follows:

1. How do students' learning experiences over the 10-week period, indicated by how creative they felt, their ability to take smart risks, express an idea, and level of ability and

knowledge, and emotion variables positive emotion, for example, "caring about engineering projects" and negative emotion, for example, "frustrated" (indicated by the ESM responses)?
2. How do these experiences vary by type of learning (something new vs. something familiar; indicated by the ESM responses)?
3. How do these experiences vary by interaction partner (alone, with peers, with faculty member; indicated by the ESM responses)?
4. How do these experiences vary by type of engineering course: winter (faculty member attended creativity workshops) versus spring (a different faculty member developed his own unique ways of infusing instruction with creativity, without attending the creativity workshops; indicated by the ESM responses)?
5. What are student perceptions of creativity in their courses (ascertained from interviews)?

METHOD

The purpose of this exploratory pilot study was to use the ESM coupled with interviews to gain insight into students' thoughts and feelings during their learning experiences in two engineering technology courses designed to promote creativity in students.

Experience Sampling Method

ESM was originally developed by psychologist Mihaly Csikszentmihalyi to study flow and creativity (Csikszentmihalyi, 1990; Csikszentmihalyi & Hunter, 2003; Hektner et al., 2007). This technique is based on the principle of contacting study participants throughout designated times to report on their thoughts and feelings in real time as opposed to filling out surveys in a retrospective manner. We were especially interested in using ESM with students during their course learning activities. For this pilot study, a commonly used ESM survey was adapted to iPods using an app for *SurveyDeck* software. Students logged onto the app on the iPods to fill out the survey (see Figure 1)—this was easier than asking them to go to a separate computer lab to log onto desktop computers and fill out surveys. Because the iPods are small and can be placed on student desks, they do not significantly interrupt the course learning activities.

A list of survey items was drafted based on three well-known experience sampling forms from the 500 Family Study and the Sloan Study of Youth and Social Development (Hektner, et al., 2007). Data collection focused on the sample of learning moments in students' course experience, which included 192 distinct "learning" moments. Students were signaled 1–2 times a week during class, except for weeks that had holidays (e.g., Thanksgiving) and exams. Students were instructed to fill out the survey as soon as they were able to within a few minutes of the original request.

Although the aforementioned studies included cognitive items, such as levels of concentration, interest, challenge, ability, and knowledge, and we consequently included them on the survey, they were not constructs of interest in this study (owing to a lack of statistical power for testing all of the outcome variables). In addition, items about the importance level of the learning activity and perceptions of success were included in the survey but not in the study. Students were provided with a series of questions in a survey designed to examine their learning experiences (see Table 1) as follows:

Time. The time of day and date were automatically collected and converted to days elapsed since the start of the first lecture of the quarter.

TABLE 1. Experience Sampling Methodology Survey Questions, Constructs, and Response Options

Question	Construct	Response Option
1. Time of day	—	Automatically collected
2. Date	—	Automatically collected
3. Student ID	—	
4. Does this activity involve learning something . . .	Cognitive outcomes	New to you, previously learned, NA (does not apply)
5. Who were you with?	Type of learning interactions	Alone, pairs, group, instructor
6. As you were beeped, were you feeling: Happy, cooperative, frustrated, strained, caring about what you are learning, irritated, relaxed, stressed, proud, productive?	Emotional experience	0 (*not at all*) to 3 (*very much*; answered for each emotion term)
7. How creative did you feel?	Creative outcomes	0 (*not at all*) to 3 (*very much*)
8. Did you enjoy what you were doing?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
9. Was this activity interesting?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
10. How well were you concentrating?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
11. Did you feel in control of the situation?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
12. How challenging was the main activity?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
13. Did you have the ability and knowledge to deal with the work?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
14. Was the work/activity important to you?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
15. Were you succeeding at what you were doing?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
16. Were you willing to take smart risks with this project?	Creative outcomes	0 (*not at all*) to 3 (*very much*)
17. Did you wish you were doing something else?	Cognitive outcomes	0 (*not at all*) to 3 (*very much*)
18. Did you express your creative idea?	Creative outcomes	0 (*not at all*) to 3 (*very much*)
19. Were others really listening to what you had to say?	Communication	0 (*not at all*) to 3 (*very much*)
20. Did you care about what others were saying?	Communication	0 (*not at all*) to 3 (*very much*)

Course. Course experience was divided into two groups: the winter course (faculty member attended creativity workshops, *MHT 314: Thermo and Heat Transfer Lab*) or the spring course (faculty member did not attend the creativity workshops but developed his own techniques for infusing the course with creativity, *MHT 401: Mechanical Design I Lab*).

Emotion in Creativity. In keeping with our framework that emotions are an intrinsic part of learning in the classroom, as well as creativity in general, we sought to capture self-reported emotions. Emotions are an understudied, but important, part of being creative in the classroom (Kaufman & Beghetto, 2009). In this survey, emotions were based on the Positive and Negative Affect Scale (Watson, Clark, & Tellegen, 1988). These emotion items were used: "happy, cooperative, frustrated, strained, irritated, relaxed, stressed, proud, friendly, and productive." Items that did not seem relevant to learning, for example, "jittery" and "hostile," were eliminated, and the term *caring about learning* was added. Several Likert-scale measures (0 [*not at all*] to 3 [*very much*]; cf. Hektner et al., 2007) were taken to assess positive affect (Are you feeling . . .): Happy, Cooperative, Caring about what you are learning, Relaxed, Proud, and Productive. These items were combined to create a positive experience score that scales from 0 to 18. As for negative experience, these were Likert-scale measures to assess whether students felt Frustrated, Strained, Irritated, and Stressed. These items were combined to create a negative experience score that scales from 0 to 12.

Other Components of Learning in a Creativity-Infused Classroom. Using the same Likert scale as positive/negative experience, we used multiple measures that assessed whether participants were able to engage in behaviors identified in the literature as related to creativity, namely the ability to take risks (Plucker & Runco, 1999; Sundheim, 2013), the ability to express one's creative idea, and how creative one feels. These items were not on the 500 Family Study and the Sloan Study of Youth and Social Development (Hektner et al., 2007). But we believed them to be important representations of students' intuitive perceptions of their own creativity while engaged in engineering technology projects.

Type of Social Interactions. Students were asked whether they were alone, paired with someone, in a group, or with the faculty member. This was recoded into the binary condition of being in a group ($N = 78$ [responses]) or being with the faculty member ($N = 39$) because only 7 of the 124 responses (recoded as missing) involved being alone ($N = 5$) or in pairs ($N = 2$), which was insufficient data to be included in the analysis. Another question asked whether the activity involved learning something, and, if so, whether the item learned was entirely new ($N = 76$) or previously learned ($N = 34$). Because only 14 of the 124 responses did not involve learning something, these 14 responses were recoded as missing data for this variable.

Communication. As part of the social component of learning, we wanted to account for the nature of communication as a key part of the creative process (e.g., Sawyer, 2007). The survey used the aforementioned 0–3 Likert scale to assess whether students cared about what others were saying, and whether they felt that others were really listening to what they had to say. These items were derived from the 500 Family Study and the Sloan Study of Youth and Social Development (Hektner et al., 2007) and are especially relevant considering the link between creativity and communication in engineers (Mann et al., 2011).

Sample and Procedures

Each engineering student participating in this study completed approximately one to two 3–5 min surveys during 3-hr classes (once per week) or one survey for 90-min classes. The ESM was administered on iPod Touch devices owned by the college (see Figure 1). Upon the start of each class in this study, all students enrolled in the courses were sent an introductory e-mail with a recruitment announcement with the consent form attached. This announcement outlined the goals of the study; informed students that participation was completely voluntary, anonymous, and confidential; and that participation would automatically enter the student to win an iPod or two $50 gift certificates through a raffle system at the end of the term. On the first day of class, a member of the research team spoke with the students in the classes, passed out consent forms, and answered any questions the students might have about this study. Once consent forms were collected, students were instructed through a short tutorial how to register their user numbers (to maintain anonymity) and take the ESM survey on iPod Touches. Twelve students in the MHT 314 class (100% participation rate) decided to participate and signed the consent forms. It should be noted that all 12 students in this class were male. In MHT 401, nine students agreed to participate, but one student dropped the course in Week 3; therefore, eight students participated (89% participation rate)—seven male and one female.

The first class for this research project began in the winter 2012–2013 (MHT 314: Thermo and Heat Transfer) and a subsequent spring class (MHT 401: Mechanical Design I Lab) with a different set of students than winter 2012–2013/MHT 314. MHT 314 explored basic thermodynamic relations[3]—students conducted experiments of the flow of compressible fluids and steam and the energy conversion of a fuel into a working substance and the related heat transfer mechanisms. MHT 401 was an introduction to mechanical design, the design process, design factors, optimization, human factors, and value engineering.

Creativity Workshops and Instructional Plans for Student Creativity

Engineering technology (ET) faculty members, in collaboration with the educational researchers with collective expertise in creativity, learning, and mathematics, met on a monthly basis during the fall of 2012 in creativity workshops. During these workshops, seminal research models on creative thinking and problem solving were introduced and discussed. A 23-page handout was given to faculty members, covering a history of seminal creativity research models and definitions (e.g., Amabile, Csikszentmihalyi, Gardner, Maslow, Osborn, Parnes, Rogers, Sternberg, Sternberg and Lubart, Torrance). Discussions started with the definition of creativity as not just “thinking outside the box,” or coming up with new ideas. Faculty debated misconceptions of creativity as frivolous, inappropriate, or purely a product of inborn talent. Research-based definitions of creativity were presented as ideas, products, or solutions perceived as novel, useful, and demonstrating excellence in a domain. Taken together, the implications of three areas of novelty, utility, and excellence were then discussed for engineering.

In particular, the idea of teaching for creative self-efficacy (Beghetto, 2006, 2009) was introduced as the idea that instructors can help students believe in their ability to think in creative ways. It was proposed that understanding creative self-efficacy is a critical element of student learning as part of the creativity workshops: If a teacher helps a learner believe in his or her creative abilities, then the learner is hypothetically more likely to generate new ideas that will enhance overall understanding and engagement in subject matter learning. The application of these psychological concepts was further explored for instruction on student engineering projects. New teaching strategies were discussed in terms of how the classes could be modified to enhance student creativity, and faculty members shared updates on their courses. Faculty members also created logs describing these modifications and submitted them to the researchers (see Table 2).

The MHT 314 (winter term) faculty member who attended these workshops used psychological approaches to infuse courses with creativity, focusing on the importance of resistance to premature closure when deriving new ideas. The MHT 314 faculty member used videos, animations, and manufacturer's data sheets from industry and research as real-world examples of the concepts being taught in the course. Students were exposed to emergent engineering technologies and the most recent research to allow them to enhance their breadth of knowledge and be able to apply this knowledge to their group projects. Examples of projects included developing a thermo-heated jacket for extreme cold weather. The faculty member teaching MHT 314 discussed how uncovering various solutions to a problem and avoiding premature closure could facilitate a wider range of answers, leading to a better chance of finding an optimal solution. One method of evaluating students' creative development was through altered homework assignments. In addition to traditional problem sets, students were presented with open-ended problems, and they were asked to defend and explain their solutions in the classroom. All students in MHT 314 were required to complete a group project that included the development of a theoretical analysis and a practical working prototype in the field of thermodynamics and heat transfer. While developing their projects, students were required to brainstorm several design concepts before choosing the one they would pursue.

The instructor for MHT 401 (spring term) did not attend the creativity workshops and described his approach to enhancing student creativity as more applied (drawing on his professional experience) than theoretical. For example, he focused on the technical aspects of engineering with a focus on the automotive industry. The instructor tried to show students how to harness their own creativity and draw on it as an important professional resource. Finally, the instructor also encouraged the student groups to share their creative approaches with each other.

INTERVIEWS

The purpose of the interviews was to gain insight into the learning process in students' course experience and complement the quantitative data collected through the ESM surveys by deepening and extending the data with student perceptions of learning in creativity-infused classrooms. After the students completed the ESM surveys, they were recruited and invited to participate in interview sessions. Eight students participated in two interview sessions. Questions posed to the students included whether they perceived creativity to be important and relevant to the field of engineering technology, how they perceived their own creative abilities (creative self-efficacy), and their feelings during the design process over the 10-week course. The design process consisted of exploring ideas to make a product, using the right types of materials to make a product, and then submitting final products to the instructor. Student comments were coded according to these themes using content analysis (Creswell, 2008) for grouping-like comments under overarching categories.

RESULTS

The results are explained chronologically: First, the ESM analysis is reviewed and then the interview analysis is explained with prominent themes coupled with in vivo quotes that exemplify those themes.

TABLE 2. Enhancements to Engineering Technology Courses Designed to Promote Student Creativity by Week

		Week									
Design	Course	1	2	3	4	5	6	7	8	9	10
Engineering technology topic	MHT 314[a]	Basic thermodynamic concepts; first and second law of thermodynamics, energy balance; review of entropy	Basic modes of heat transfer; heat conduction	Heat conduction	Convective heat transfer	Nusselt number, convection heat transfer coefficients	Convective heat transfer: natural convection	Forced convection; Intro to radiation	Heat exchangers	Heat exchangers	Project presentations
	MHT 401	Aspects of machine design	Computer aided design	Permanent connections; detachable fasteners	Springs, keys, couplings, sliding and rolling element bearings	Mechanical clutches; mechanical brakes	Belt drives; chain drives	Spur and helical gears	Gears for nonparallel shafts; patent attorney presentation	n/a Holiday No class	Final exam—defend an explanation of students' projects
Instructors' enhancements to student creativity	MHT 314[a]	Real-life examples; links between the theoretical and practical approach Open-ended questions and debates Lab experiment: vortex tube	Open-ended questions and lab experiment Students explore basic fundamentals of heat transfer and heat conduction.	Open-ended questions and lab experiment Students explore basic fundamentals of heat transfer and heat conduction.	Same	Same	Knowledge enhancement stage Lab experiments: critical analysis of the experimental data pertinent to various nondimensional numbers Similarity analysis	Lab experiments: critical analysis of the experimental data pertinent to various nondimensional numbers Similarity analysis	Latest technologies in heat exchangers Enhancing enhance student flexibility and fluency and also to stimulate creative thinking and resistance to premature closure	Same	Emphasis on originality, tolerance of ambiguity, resistance to premature closure, and risk taking Fluency, flexibility, and elaboration were used more during the experiential activities,

				Lab experiments: critical analysis of the experimental data			Open-ended questions; critical thinking and resistance to premature closure	Open-ended questions during both lecture and lab activities			and intrinsic and extrinsic motivations were more employed during the lecture portion of the course.
	MHT 401	Accentuated the value of the engineering profession and a Professional Engineer title	Informed students of up-to-date, powerful design methods	Familiarized students with English and metric systems	Students and instructor bring real machine parts to the lecture to share with class.	Showed students real parts, mostly from the automotive industry	Instructed students how to properly and intelligently choose from already existing solutions	Students and instructor brought examples of gears and gear drives to the lecture to share with class.	Showed students how to protect and take advantage of their creativity	n/a	Allowed students to share in the creativity in each other's projects
Perceived level of difficulty compared to previous weeks	MHT 314[a]	n/a	Same	Harder	Harder	Harder	Same	Same	Harder	Same	Easier
	MHT 401	n/a	Harder	Easier, especially for students with industrial experience	Slightly harder because of calculation of required forces	Slightly harder because of required calculations of forces and energy	Easier because designers chose from available catalogs	Hard because the parts have complicated geometry	Harder than Lecture 7 because of 3D geometry	n/a	Easier than in previous weeks, especially for those who carefully did their projects.

Note. MHT 314 = MHT 314: Thermo and Heat Transfer Laboratory (Winter 2013); MHT 401 = MHT 401: Mechanical Design I Lab (Spring 2013); 3D = three-dimensional.
[a]Instructor attended creativity workshop series.

Experience Sampling Method Analysis

For the experience sampling (ESM) survey responses (the first part of the study), we focused our analysis on the response-level data. For each student in the winter and spring classes, we had three or more responses. Because the analysis plan was including data assessed over time, we wanted to have at least five data points per student to make a trend. We deleted responses from four students who had fewer than the requisite five responses (two of them had only one response, one had two responses, and one had four responses). In addition, faculty members decided not to administer the ESM surveys during exam week (Week 5; both courses) and holiday week (e.g., Thanksgiving; MHT 314), which further limited the amount of usable survey responses. In the end, 192 survey responses were deemed usable for analysis.

We used mixed models using students' learning experiences as the outcome and time, social aspects (i.e., type of learning and interaction partner), and session (winter, spring) as the factors. We began by running models that contained all of the factors and including two-way interactions between time and the other factors and then removing factors that had no impact on the model. Given the small sample size, we did not expect three-/four-way interactions, and many of the other potential two-way interactions are beyond the scope of this study. All of the outcome variables had absolute skewness and kurtosis values below 1.5, which is considered sufficient for assumptions of normality (Tabachnick & Fidell, 2012). In anticipation of family-wise error because of the number of models, we reduced the alpha criterion to .01 for final models (.05 for initial models to maximize sensitivity to potentially significant effects). We opted against the highly conservative Bonferroni adjustment because of concerns that it would reduce power by too great of a factor (cf. Nagakawa, 2004).

Positive Emotional Experience. A mixed model including all of the factors showed only an interaction between time and session, with a fixed-effect interaction estimate of 0.11 (±0.04; $t = 2.46$, $p = .02$). To conserve explanatory power, a second model was run using only time and session as factors, the estimates of which are shown in Table 3 and Figure 2[4] in the following text. As session was coded as (0 = winter; 1 = spring), SPSS treated the winter session as the baseline. Thus, the fixed effect of time (which SPSS treats as pertaining to the group with the lower code [winter]) indicates that positive experience decreased over time in the winter session. The interaction effect, however, suggests that the people in the spring session experienced a slight increase in positivity of experience over and above the effect found for the winter group (0.15 + [−0.07] = .08). Given that positive experience was a combination of six variables measured on a scale of 0–3 (and thus has a range of 0–18), a change of .08, although significant, is a small effect. Nonetheless, to find any effect with such a small sample size is

TABLE 3. Fixed Effects for a Mixed-Model Analysis of Factors Affecting Positive Experience

Factor	Estimate	Standard Error	*t*
Intercept	9.03	0.64	14.04***[a]
Time	−0.07	0.02	3.61**
Season	−0.85	1.33	−0.64
Time × Season	0.15	0.04	3.59**

*$p < .05$. **$p < .01$. ***$p < .001$.

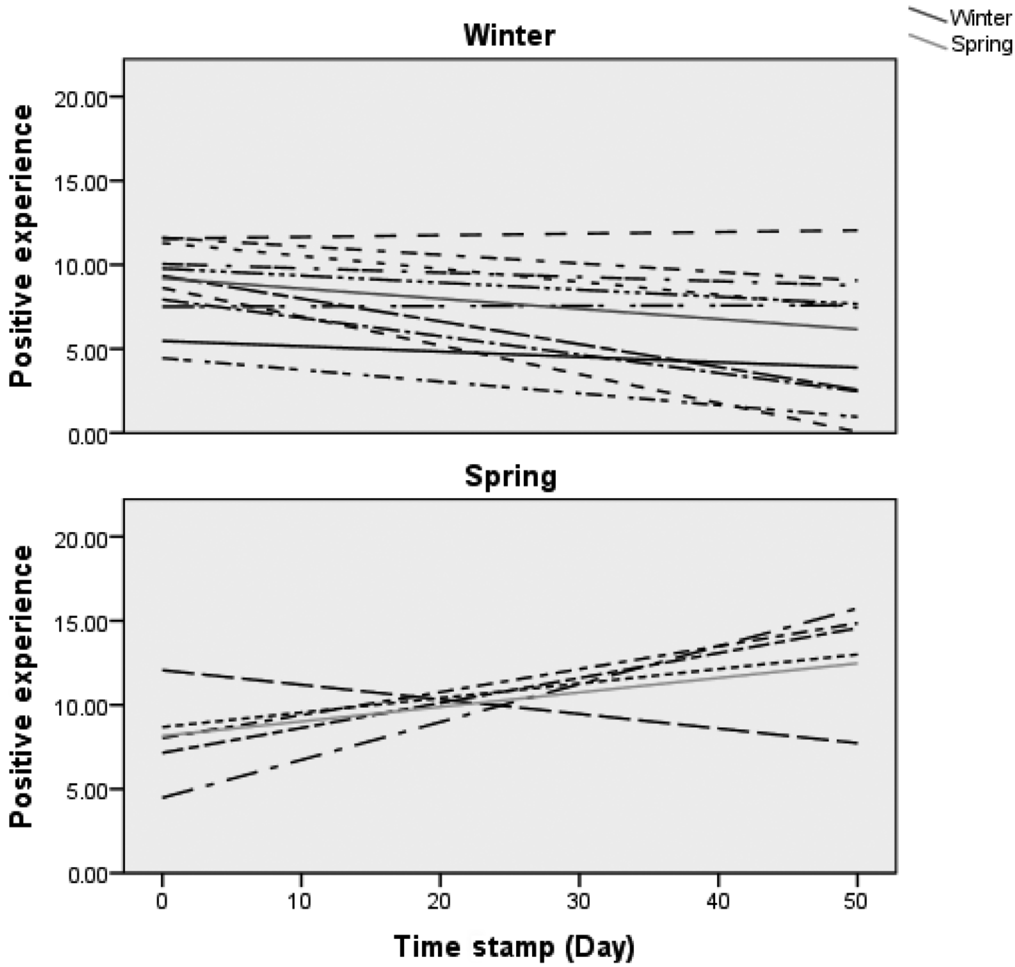

FIGURE 2. Spaghetti plot of positive experience by course.

notable, especially given the large residual (7.16 ± 1.09 on the 0–18 scale; Wald $Z = 6.45$, $p < .001$), and this warrants further study.

Negative Emotional Experience. Unlike the case of positive experience, negative experience did not show anything significant in the initial model. We decided that it was reasonable to check for an effect of time and session because they had an effect on positive experience. Results showed that being in the latter session had a strong impact on negative experience (2.68, ±1.01, $t = 2.66$, $p < .01$), but this effect did not change over time (see Table 4 and Figure 3). Again, the residual was large (6.56 ± 0.99 on the 0–12 scale, Wald $Z = 6.63$, $p < .001$) but so is the effect, in this case. Taken together with the results of positive experience, and the fact that each session had a different teacher and material, the data suggest that the teacher or course material can have a serious impact on the positivity/negativity of the student learning experience.

Feeling Creative. On whether participants felt creative during the courses, none of the factors were significant.

Taking Smart Risks. The initial model indicated that the only variable that did not impact this outcome is whether one learned something. As shown in Table 5 and Figure 4, there were

TABLE 4. Fixed Effects for a Mixed Model Analysis of Factors Affecting Negative Experience

Factor	Estimate	Standard Error	*t*
Intercept	4.24	0.44	9.71***
Time	0.06	0.11	0.49
Season	2.68	1.01	2.66**
Time × Season	−0.12	0.20	0.60

$*p < .05$. $**p < .01$. $***p < .001$.

several fixed effects, the first of which is that this factor decreased slightly over time. Second, there is an effect of type of course (winter/spring), which shows that willingness to take smart risks was significantly higher in the spring course. Being with the instructor seemed to have a slight impact on willingness to take smart risks over the timespan of the course. Although this effect is too small to be meaningful (even on a scale of 0–3), it warrants being watched in

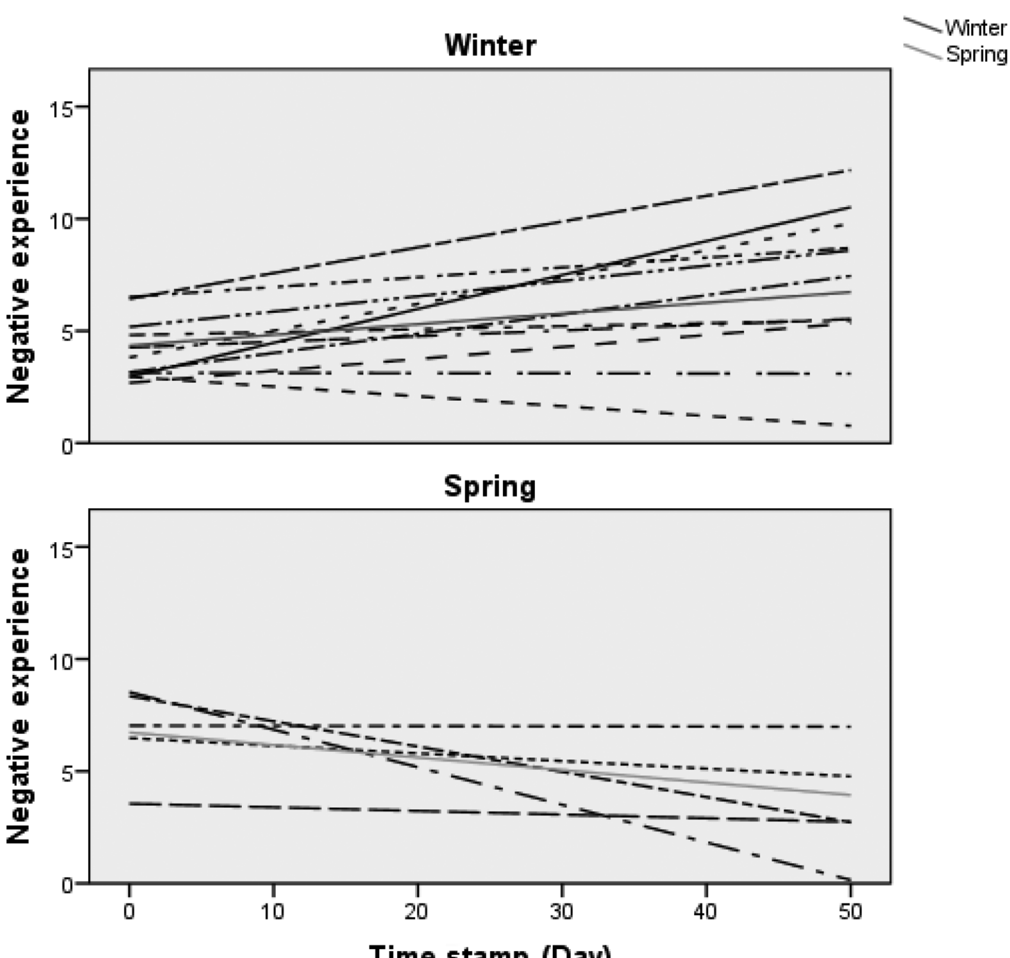

FIGURE 3. Spaghetti plot of negative experience by course.

TABLE 5. Fixed Effects for a Mixed Model Analysis of Factors Affecting Willingness to Take Smart Risks

Factor	Estimate	Standard Error	*t*
Intercept	2.25	0.72	3.10*
Time	−0.08	0.03	2.48*
Learned something new (yes/no)	0.22	0.15	1.44
Companion (group vs. instructor)	−0.40	0.22	1.85
Season	1.16	0.49	2.38*
Time × Learned Something New	0.01	0.01	1.23
Time × Companion	0.02	0.01	2.37*
Time × Season	−0.001	0.02	0.08

*$p < .05$. **$p < .01$. ***$p < .001$.

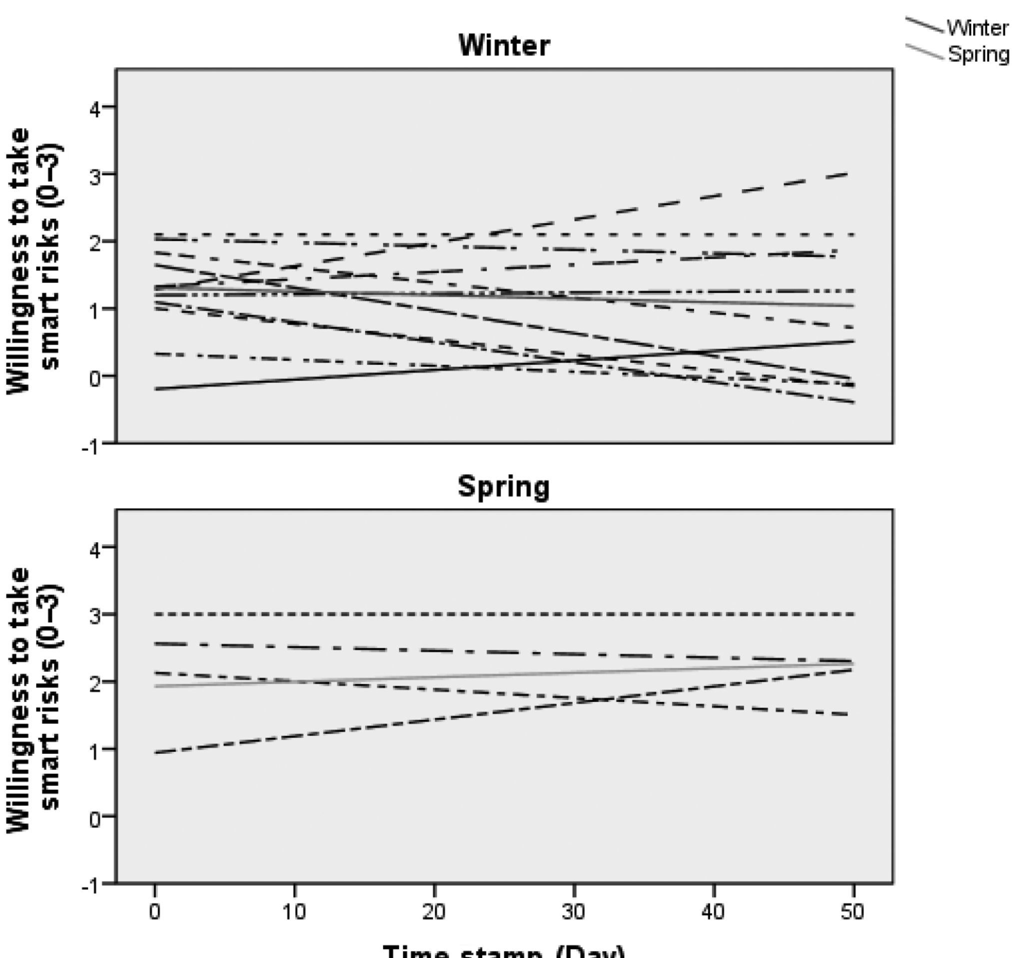

FIGURE 4. Spaghetti plot of willingness to take smart risks by course.

TABLE 6. Fixed Effects for a Mixed Model Analysis of Factors Affecting Willingness to Express a Creative Idea

Factor	Estimate	Standard Error	t
Intercept	3.80	0.94	4.04***
Time	−0.03	0.03	1.05
Companion (group vs. instructor)	−0.78	0.29	2.72**
Time × Companion	0.01	0.01	1.16

$*p < .05$. $**p < .01$. $***p < .001$.

future studies. Relative to the scale of 0–3, the residual was large (0.56 ± 0.07, Wald Z = 8.21, $p < .001$), and thus, it is notable that the effect of type of course was so high.

Willingness to Express Creative Idea. An initial model showed that one's company (group or instructor; $-.84 \pm .29$, $t = 2.85$, $p = .006$) was a predictor of whether one is willing to express a creative idea. A second model (Table 6 and Figure 5) showed that this was a

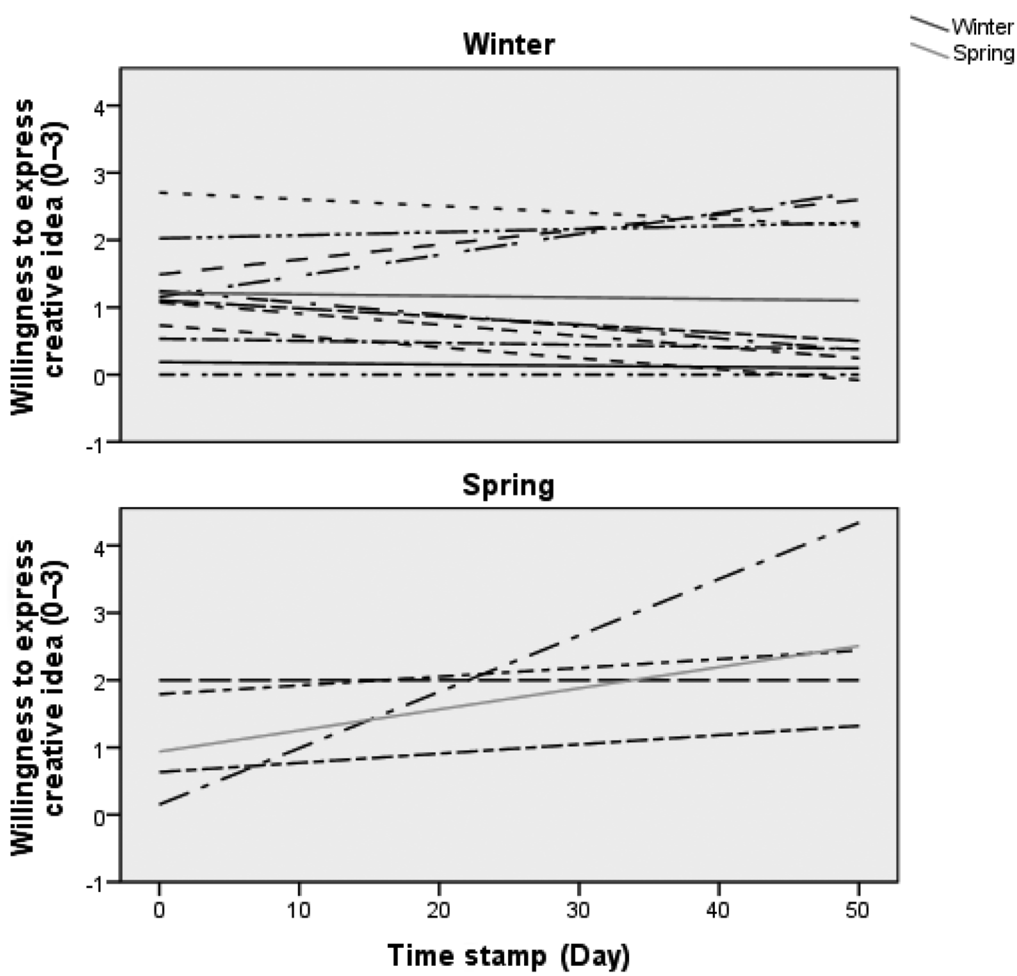

FIGURE 5. Spaghetti plot of willingness to express creative ideas by course.

TABLE 7. Fixed Effects for a Mixed Model Analysis of Factors Affecting Whether Others Were Perceived as Really Listening

Factor	Estimate	Standard Error	t
Intercept	4.45	1.07	4.15***
Time	−0.05	0.04	1.39
Companion (group vs. instructor)	−0.87	0.33	2.63**
Time × Companion	0.01	0.01	1.31

$*p < .05$. $**p < .01$. $***p < .001$.

fixed effect. Because being with a group was the lower coding, the results suggest that being with the instructor implies a lower willingness to express a creative idea relative to being with a group and that this effect does not change over time (given the lack of interaction). The residual is relatively high (0.57 ± 0.10 on a scale of 0–3, Wald $Z = 5.41$, $p < .001$), which emphasizes the fact that the effect of interaction partner is a telling one.

Were Others Really Listening. The factors contributing to whether others were really listening almost exactly matched the willingness to express the creative idea. One's company was a predictor of whether one feels that others are really listening (-0.91 ± 0.34, $t = 2.70$, $p = .008$). A reduced model (Table 7 and Figure 6) showed a fixed effect that does not change over time and being with an instructor resulting in slightly lower feelings that others are listening. The residual is relatively high (0.60 ± 0.10 on a scale of 0–3, Wald $Z = 5.79$, $p < .001$), which likewise implies a meaningful effect.

Did you care about what others were saying? No factors were significant in predicting whether one cared about what others were saying. Although whom someone was with was significant in the initial model at the .05 level, it was not significant in a reduced model.

Interview Analysis

The following themes that emerged from interviews with eight engineering technology students are reported here: perceptions of creativity as domain-specific, perceptions of creative self-efficacy, and perceptions of creativity during the design process. As part of the interview, students were also asked to draw diagrams of the different design stages they experienced in the engineering process and then identify their predominant emotional focus within each stage to help clarify when they experienced positive and negative emotions.

Perceptions of Creativity as Domain-Specific. Students were struck by the engineering industry's interest in creativity as driving the need for young, creative engineers, and they generally perceived creativity as domain-specific to the field of engineering technology. For example, one student said, "Everything is driven by ideas, and you need to be creative to have ideas. Everything starts with an idea and progresses from there."

Another student pointed out that "I think the ability to work with other people is really important. The ability to share your ideas clearly with others." This comment emphasizes the importance of the quality of communication, which is especially important for engineering technology students working in groups. Students valued the ability to effectively express their design ideas with their peers.

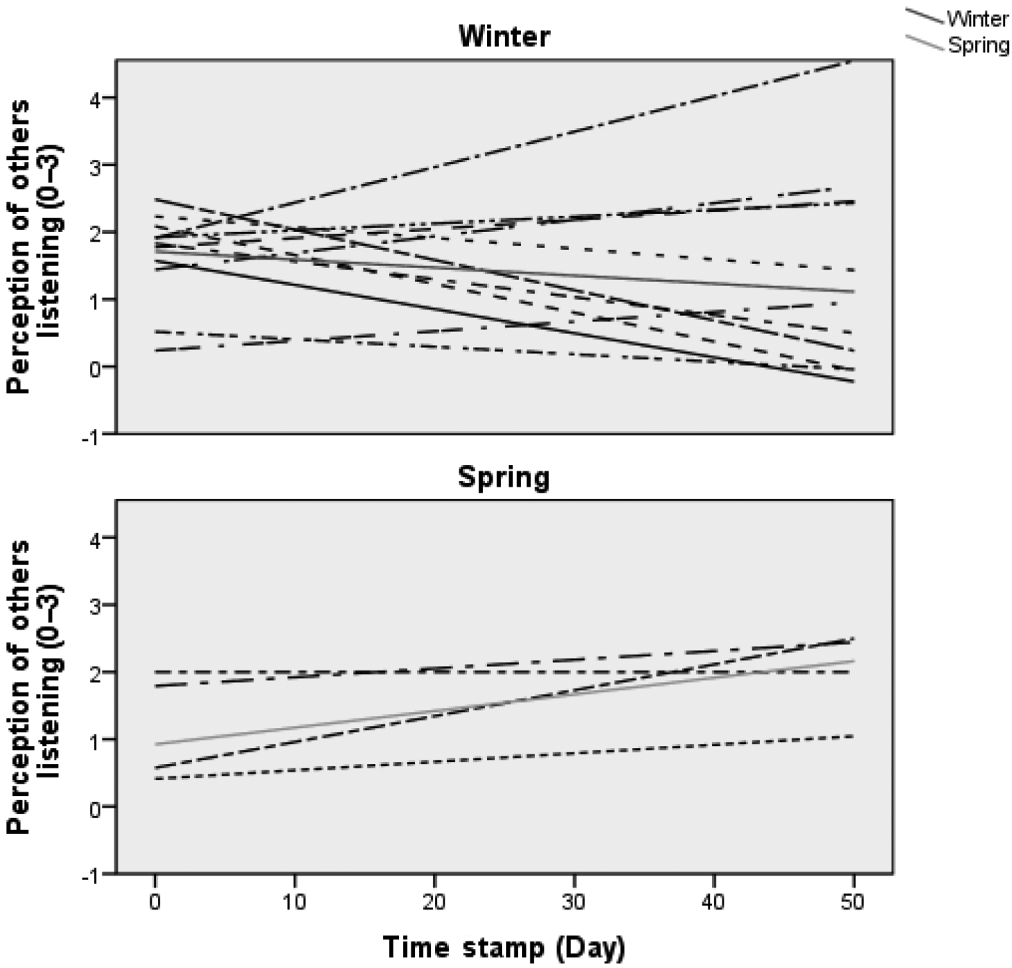

FIGURE 6. Spaghetti plot of perception of others listening by course.

Students also described how an engineer must believe in his or her own abilities and establish a substantial base of past knowledge to be creative and innovative. This reflects the utility and relevance dimension of creativity. For example, one student said,

> You must be able to manipulate past methodologies and see how you can adapt them for current problems . . . . We have discussed the role of the engineer more of an innovator than of an inventor. I think a broad knowledge base is very important for a creative engineer. Then you can cite how people may have addressed similar problems in the past.

Another student remarked that a “fresh set of eyes” and “new outlooks” were essential reasons for bringing in new, young engineers to bridge the gap with older engineers’ approaches. Overall, the students perceived creativity as a beneficial asset for the engineering industry.

Perceptions of Creative Self-Efficacy. Students reflected on their creative self-efficacy, or perceived ability for deriving new ideas in their group projects:

> Before this study, I never really thought about creativity or how creative I am. It was just part of my day. Some of these questions made me realize some new aspects that influence creativity. Sometimes, I wasn't feeling very creative because I was just waiting for the [engineering technology] data to collect. In other situations where I am analyzing the data and going back to previous class notes, then I feel a little more creative . . . . I think you have to be not only creative but innovative. You have to come up with new ideas.

Here, the student noted how his "creative feeling" was stronger when combining the act of data collection with making sense out of his course lecture notes. This implies that the hands-on nature of the group project combined with listening to lectures fueled his creativity.

Overall, students indicated that they wanted to become more creative in their courses and that they believe creativity was "circumstantial." One student, although, questioned how he could actually develop and apply creativity in his coursework. Another student declared, "I work for intrinsic reward more than being recognized by other people." These comments suggest that the student did believe in his ability to be creative (creative self-efficacy) in the context of being creative in the classroom. In fact, he said that extrinsic rewards could "stifle" creativity.

Perceptions of Creativity During the Creative Design Process. In addition to talking about the importance of creativity to engineering technology, students also discussed how they felt during the end of the engineering technology design phase:

> I'd say you're usually pretty happy, unless the parts you need for your design are really hard to get and put into action. I think when you design something you feel pretty happy and have a feeling of accomplishment. The design phase makes you excited and happy.

He also commented that his creative self-efficacy could be enhanced by the instructor's input: "I think professors' enthusiasm for their subject has a lot to do with inspiring creativity in their classes. If they care about what they're teaching, then you're going to care more about what you're learning." This comment implies that the instructor's support influenced the student's ability to care about what he was learning in the course. The student also emphasized how his feelings changed during creative design process in the drawing of the design diagram.

DISCUSSION

This exploratory pilot study used the ESM and interviews to gain insight into students' thoughts and feelings during their learning experiences in two engineering technology courses designed to promote creativity. The learning experiences were analyzed using mixed models to provide a picture of student engagement in the context of two different types of creativity-enhanced engineering curricula.

Students in this study experienced a decrease in positive emotions toward the end of the course as indicated in the ESM analysis. Although precise reasons cannot be attributed to this decrease, the interviews do offer insight: Students commented on the episodic nature of positive and negative feelings during engineering design phases. For example, one student emphasized that the "design phase" made him "excited and happy" at the beginning of the course. He further noted that he felt stressed when facing constraints of the materials used in his project toward the middle of the course as well as when he was nearing an impending assignment deadline at the end of the course. Therefore, it is possible that students' positive emotions decreased toward the end of the course when their final projects were due, which implies apprehension based on evaluation (Rosenberg, 2009).

In the spring course, the faculty member did not attend the creativity workshops that the winter instructor had intended. Instead, he drew on industry experience to develop methods for supporting creativity in students. For students in this course, being with the instructor seemed to have a slight impact on willingness to take smart risks over the timespan of the course. In addition, students also reported a slight increase in their positive experience. Although this calls into question the efficacy of the creativity workshops for the fall faculty member, as well as the resulting instruction, we note that the deeper implication is that placing different emphases on aspects of instruction can have differential effects on students' experiences.

In addition to the differences perceived by the students between these two courses, there were some additional unexpected results. Overall, being with the instructor implied a lower willingness to express a creative idea relative to being with a group of peers. This can be interpreted in several ways. First, this result implies that peer relationships were more conducive to sharing creative ideas than student–faculty relationships. This might be explained, to some extent, with research on social influence processes (Festinger, 1954) and the formation of social identity (Tajfel & Turner, 1986) within groups attempting to perform creatively. The social identity of the students might have been stronger when in the presence of their peers than when working in the presence of the faculty members. As a result, students might have compared their own creative self-efficacy as a group with the faculty member's creativity. This social comparison might have hindered student beliefs in their collective ability to be creative because the faculty member was already a successful engineer. The students might have made what is called an "upward comparison" (Gibbons & Darley, 1987) to the faculty member counterparts, whom they perceived as being more creative. This upward comparison might have resulted in feeling less motivated to express one's creative ideas, instead of feeling inspired to reach one's creative potential.

It is possible the presence of the faculty member symbolized the need to concentrate on task structure and signified that their work was going to be assessed and graded (again, implying the effect of evaluation). In turn, this could have prematurely inhibited students' creative idea expression. Students with this novice level of expertise in engineering technology might not have effectively monitored their goals and therefore viewed the faculty member as an imposition on their creative ideas. It could be that students perceived more psychological safety (Edmondson, 1999), or optimal group conditions of emotional engagement, safety, and support (Paulus & Nijstad, 2003) among their peers.

In this pilot study, students perceived that their peers listened better to what they were saying, even though there were no differences between peer and instructors caring about what they were saying. This result was also emphasized in the interviews, when students remarked about the importance of the "ability to share your ideas clearly with others." Thus, the quality of communication might be more conducive to supporting idea generation among *students* (cf. Cannon-Bowers, Tannenbaum, Salas, & Volpe, 1995; Driskell, Goodwin, Salas, & O'Shea, 2006) rather than student–faculty interactions. This raises the question of how faculty members might cultivate a learning climate more conducive to listening so that students perceive that their ideas are included more prominently in whole-class discussion and student–instructor dialogue. In that sense, faculty members can help students develop a sense of community so that they are more likely to cooperate and engage in a free exchange of ideas (Hulsheger, Anderson, & Salgado, 2009). In turn, the sense of freewheeling communication can be better tapped as a source of learning to generate synergy within peers (Sawyer, 2007).

Regarding study limitations, we wish to note that although we were careful to separate the instruction from survey administration and therefore minimize social desirability bias (Messick & Jackson, 1961), the sample size of responses remained a limitation for analysis. Because the repeated sampling over time necessitated the use of mixed-model analyses, it was difficult to get enough data for effects to emerge. That said, we did find several factors that clearly affect the learning experience of students, and we hope that future studies can determine the relative importance of these factors so as to further develop creativity-based educational environments for engineering and other students. Another limitation to the study is that not all of the students participated in the interviews, and therefore, the interview results do not represent the full range of perspectives on both engineering technology courses.

Overall, this pilot study showed that student experiences can be tracked, and important effects elicited, even with gender-biased classes of small size. Although the implications of the specific findings should be tempered with the knowledge of these limitations, we have shown the importance of placing emphasis on infusing instruction with a focus on developing creative capacities both in general and with reference to the domain. Such an effort can lead to positive results in student learning and engagement, and we hope that future studies will expand on emotional and social components of learning in classrooms designed to promote creativity. Moreover, we reiterate the value of using ESM as an adjunct to student evaluations to assess not just retroactive assessments of students' experiences but also a dynamic picture that can give an instructor a more detailed view of how students' learning experiences progress over the course of their studies.

The results from this study also point toward the need to use a multipronged approach to encouraging student creativity in the higher education classroom. This study focused on instructor training, curriculum, and the fluid, dynamic assessment of students' self-reported learning coupled with interviews. But, the results imply that instruction about creativity alone does not suffice as a way to ensure learning outcomes. Rather, in-depth coaching to promote peer-assisted (i.e., student-level) support of creativity can help strengthen group work. This is because although the instructor who taught the winter course had attended the creativity workshops, students reported a slight decrease in their positive experiences. This particular result appears contradictory with past research showing that positive emotions are affiliated with learning experiences focused on being creative. As noted in the literature review, mild positive affect has been associated with idea exploration, cognitive flexibility, and even task performance (Isen, 2008). Other researchers link positive emotions to academic achievement and note that negative emotions can impede academic performance (Mega et al., 2013).

Willingness to express a creative idea with a group of peers suggests the curricular and instructional need to promote the peer-supported creativity rather than concentrating primarily on enhancing instructor-supported creativity. The creativity workshops focused solely on introducing creativity theories and models to engineering faculty members, but further workshops should also focus on putting the students at the heart of the design process. We note that the workshop on creativity was focused primarily on the *definitions and theories* of creativity and not on the contexts that foster creative ideation (such as positive emotions). Therefore, our results suggest that future trainings and studies place more emphasis on contextual factors. This is consistent with the research on teamwork, which suggests that the role of leadership is support, guidance, and encouragement but that it is crucial for the team itself to have a level of trust that promotes honest and open communication (Isaksen & Lauer, 2002; Sawyer, 2007) as well as explicit support from coworkers (Madjar, Oldham, & Pratt, 2002). As such, instructors become responsible for helping students communicate efficiently (e.g., Salas, Cooke, & Rosen, 2008), which is essential to groupwork in engineering (Mann et al., 2011).

To that end, future studies can also consider linking evaluations of coursework (e.g., quality, creativity) from the perspectives of students, peers, and faculty to the context (e.g., emotions) in which the work is produced. Likewise, it would be informative to track the role of contextual factors such as emotion with respect to their impact on future willingness to engage in creative processes (and the consequent changes in the quality of engineering projects). Ultimately, promoting creativity in the classroom is a complex process with many factors, but the results of this pilot study have highlighted several key areas for new directions in creative education and cognition.

NOTES

1. This study is part of a 2-year collaboration between educational researchers, psychologists, and engineering and engineering technology faculty members, funded by a National Science Foundation Research Initiation grant in Engineering Education.

2. For example, the engineering course textbook *Reinforced Concrete Design* (Aghayere & Limbrunner, 2014) describes an assignment that requires students to derive creative solutions within the parameters of the applicable building design code (Dhillon, 2006).

3. The first group was enrolled in a section of *MHT 314: Thermo and Heat Transfer Lab* (winter 2013) whose instructor attended a series of creativity workshops (see in the following text). The second group of students was enrolled in a section of *MHT 401: Mechanical Design I Lab* (spring 2013) whose instructor did not attend these workshops but developed his own ways for infusing creativity into his course. These courses are required in the engineering technology curriculum, including both design and final project components as well as a blend of theory and practical applications. In addition, these were the only two courses offered to juniors during the 2013–2104 year and were part of the grant timeline. Engineering technology faculty believed that these particular courses would best allow for student creativity compared to other courses.

4. All figures of mixed models show the dependent variable only over time and season because a multidimensional graph becomes visually unwieldy in two-dimensional space.

REFERENCES

Aghayere, A. O., & Limbrunner, G. F. (2014). Reinforced concrete design (8th ed.). Upper Saddle River, NJ: Pearson/Prentice Hall.

Amabile, T. M. (1996). *Creativity in context*. Boulder, CO: Westview Press.

Beghetto, R. A. (2006). Creative self-efficacy: Correlates in middle and secondary students. *Creativity Research Journal, 18*, 447–457.

Beghetto, R. A. (2009). Correlates of intellectual risk taking in elementary school science. *Journal of Research in Science Teaching, 46*(2), 210–223.

Beghetto, R. A., & Baxter, J. (2012). Exploring student beliefs and understanding in elementary science and mathematics. *Journal of Research in Science Teaching, 49*, 942–960.

Beghetto, R. A., Kaufman, J. C., & Baxter, J. (2011). Answering the unexpected questions: Exploring the relationship between students' creative self-efficacy and teacher ratings of creativity. *Psychology of Aesthetics, Creativity, and the Arts, 54*, 342–349.

Cannon-Bowers, J. A., Tannenbaum, S. I., Salas, E., & Volpe, C. E. (1995). Defining competencies and establishing team training requirements. In R. Guzzo & E. Salas (Eds.), *Team effectiveness and decision making in organizations* (pp. 333–380). San Francisco, CA: Jossey-Bass.

Cropley, A. J. (2006). Creativity: A social approach. *Roeper Review, 28*, 125–130.

Cropley, D. H., & Cropley, A. J. (2000). Fostering creativity in engineering undergraduates. *High Ability Studies, 11*(2), 207–219.

Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research*. Upper Saddle River, NJ: Pearson Education.

Csikszentmihalyi, M. (1990). *Flow: The psychology of optimal experience*. New York, NY: Harper & Row.

Csikszentmihalyi, M. (1996). *Creativity: Flow and the psychology of discovery and invention*. New York, NY: Harper Perennial.

Csikszentmihalyi, M., & Hunter, J. (2003). Happiness in everyday life: The uses of experience sampling. *Journal of Happiness Studies, 4*(1), 185–193.

Csikszentmihalyi, M., Rathunde, K., & Whalen, S. (1993). *Talented teenagers: The roots of success and failure*. New York, NY: Cambridge University Press.

Dhillon, B. S. (2006). *Creativity for engineers*. Singapore, Singapore: World Scientific.

Dowd, E. T. (1989). The self and creativity. In *Handbook of creativity* (pp. 233–242). New York, NY: Springer Publishing.

Driskell, J. E., Goodwin, G. F., Salas, E., & O'Shea, P. G. (2006). What makes a good team player? Personality and team effectiveness. *Group Dynamics: Theory, Research, and Practice, 10*(4), 249–271.

Dweck, C. S. (1986). Motivational processes affecting learning. *American Psychologist, 41*(10), 1040–1048.

Edmondson, A. (1999). Psychological safety and learning behavior in work teams. *Administrative Science Quarterly, 44*, 350–383.

Felder, R. (1988). Creativity in engineering education. *Chemical Engineering Education, 22*(3), 120–125.

Festinger, L. (1954). A theory of social comparison processes. *Human Relations, 7*, 117–140.

Gibbons, F. X., & Darley, J. M. (1987). Social comparison theory: Self-evaluation and group life. In B. Mullen & G. R. Goethals (Eds.), *Theories of group behavior* (pp. 27–47). New York, NY: Springer Publishing.

Goel, A. K. (1997). Design, analogy, and creativity. *Institute of Electrical and Electronics Engineers Expert, 12*(3), 62–70.

Hektner, J. M., Schmidt, J. A., & Csikszentmihalyi, M. (2007). *Experience sampling method: Measuring the quality of everyday life*. Thousand Oaks, CA: Sage.

Hulsheger, U. R., Anderson, N., & Salgado, J. F. (2009). Team-level predictors of innovation at work: A comprehensive meta-analysis spanning three decades of research. *Journal of Applied Psychology, 94*(5), 1128–1145.

Hunter, J. P., & Csikszentmihalyi, M. (2003). The positive psychology of interested adolescents. *Journal of Youth and Adolescence, 32*(1), 27–35.

Isaksen, S. G., Dorval, K. B., & Treffinger, D. J. (2011). *Creative approaches to problem solving: A framework for innovation and change*. Thousand Oaks, CA: Sage.

Isaksen, S. G., & Lauer, K. J. (2002). The climate for creativity and change in teams. *Creativity and Innovation Management, 11*(1), 74–86.

Isen, A. M. (2008). Some ways in which positive affect influences decision making and problem solving. In M. Lewis, J. M. Haviland-Jones, & L. F. Barrett (Eds.), *Handbook of emotions* (3rd ed., pp. 548–573). New York, NY: Guildford Press.

Kaufman, J. C., & Beghetto, R. A. (2009). Creativity in the schools: A rapidly developing area of positive psychology. In R. Gilman, E. S. Huebner, & M. J. Furlong (Eds.), *Handbook of positive psychology in schools* (pp. 175–196). New York, NY: Routledge.

Liu, Z., & Schonwetter, D. J. (2004). Teaching creativity in engineering. *International Journal of Engineering Education*, *20*, 801–808.

Majdar, N., Oldham, G., & Pratt, M. G. (2002). There's no place like home? The contributions of work and non-work creativity support to employees' creative performance. *Academy of Management Journal*, *45*, 757–767.

Mann, E. L., Mann, R. L., Strutz, M. L., Duncan, D., & Yoon, S. Y. (2011). Integrating engineering into K-6 curriculum: Developing talent in the STEM disciplines. *Journal of Advanced Academics*, *22*(4), 639–658.

Mega, C., Ronconi, L., & De Beni, R. (2013). What makes a good student? How emotions, self- regulated learning, and motivation contribute to academic achievement. *Journal of Educational Psychology*, *106*, 121–131. http://dx.doi.org/10.1037/a0033546

Messick, S., & Jackson, D. N. (1961). Acquiescence and the factorial interpretation of the MMPI. *Psychological Bulletin*, *58*(4), 299–304.

Nakagawa, S. (2004). A farewell to Bonferroni: The problems of low statistical power and publication bias. *Behavioral Ecology*, *15*(6), 1044–1045.

Paulus, P. B., & Nijstad, B. A. (Eds.). (2003). *Group creativity: Innovation through collaboration*. New York, NY: Oxford University Press.

Plucker, J. A., & Runco, M. A. (1999). Enhancement of creativity. In M. A. Runco & S. R. Pritzker (Eds.), *Encyclopedia of creativity* (Vol. 1, pp. 669–675). New York, NY: Academic Press.

Puccio, G. J., Mance, M., & Murdock, M. C. (2011). *Creative leadership: Skills that drive change* (2nd ed.). Thousand Oaks, CA: Sage.

Reisman, F. K. (2010). Creative and critical thinking in biomedical research. In Y. K. Gupta, G. Jagadeesh, S. Murthy, & A. Prakash (Eds.), *From getting started in research to presenting data in a scientific paper* (pp. 2–17). Auckland, New Zealand: Wolters Kluwer Health.

Rosenberg, M. (2009). The conditions and consequences of evaluation apprehension. In R. Rosenthal & R. L. Rosnow (Eds.), *Artifacts in behavioral research* (pp. 211–264). New York, NY: Oxford University Press.

Salas, E., Cooke, N. J., & Rosen, M. A. (2008). On teams, teamwork, and team performance: Discoveries and developments. *Human Factors*, *50*(3), 540–547.

Sawyer, R. K. (2007). *Group genius: The creative power of collaboration*. New York, NY: Basic Books.

Schneider, B., & Waite, L. J. (Eds.). (2005). *Being together, working apart: Dual-career families and the work-life balance*. New York, NY: Cambridge University Press.

Silver, E. A. (1997). Fostering creativity through instruction rich in mathematical problem solving and problem posing. *ZDM Mathematics Education*, *29*(3), 75–80.

Spooren, P., Brockx, B., & Mortelmans, D. (2013). On the validity of student evaluation of teaching: The state of the art. *Review of Educational Research*, *83*(4), 598–642.

Standards for Success. (2003). *What it takes for students to succeed America's research universities*. Eugene, OR: Center for Educational Policy Research, University of Oregon.

Sternberg, R. J., Jarvin, L., & Grigorenko, L. (2009). *Teaching for wisdom, intelligence, creativity, and success*. Thousand Oaks, CA: Sage.

Sundheim, D. (2013). *Taking smart risks: How sharp leaders win when stakes are high*. New York, NY: McGraw Hill.

Tabachnick, B. G., & Fidell, L. S. (2012). *Using multivariate statistics* (6th ed.). New York, NY: Pearson.

Tajfel, H., & Turner, J. C. (1986). The social identity theory of intergroup behavior. In S. Worchel & W. G. Austin (Eds.), *Psychology of intergroup relations* (pp. 7–24). London, United Kingdom: Academic Press.

Turner, J. E., & Husman, J. (2008). Emotional and cognitive self-regulation following academic shame. *Journal of Advanced Academics*, *20*(1), 138–173.

Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, *54*(6), 1063–1070.

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