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College students' views of creative process instruction across disciplines

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ABSTRACT

Learning about the "creative process" helps students as they undertake creative activities within a discipline. Instruction about how to create may involve a variety of pedagogical approaches across disciplines. Our study documents how college students learn about creative process through a study of their reported course experiences. We surveyed over 450 university students in nineteen different courses across five different disciplines: the Arts, Education, Engineering, Humanities, and Social Sciences. We focused on students' perceptions of their educational experiences, the perceived contributions of specific pedagogical components, and their assessment of the course's impact on their own creative development. We performed both quantitative and qualitative analyses of the students' reports. The main finding was a high degree of commonality in students' perceptions of effective learning experiences across disciplines. Common themes included open-ended projects, practice on exercises, and instructor feedback. Analyses revealed a greater perceived impact of instruction in the humanities, social sciences, and the arts compared to engineering and education. The results of the study document the qualities of learning experiences in university classrooms during creative process instruction. Suggested improvements of pedagogy include building a repertoire of successful works within a field, and self-reflection about the creative process.

1. Introduction

Creative thinking is an "essential learning outcome" for a college education (National Leadership Council for Liberal Education and America's Promise, 2007, p. 12). This agenda includes the traditional "creative" disciplines – arts and humanities – along with the natural and social sciences (Wince-Smith, 2006). In professional schools, including business (Harvard Business School Press, 2003; Kirby, 2004) and engineering (ABET Board of Directors, 2011), creative thinking is now viewed as critical in confronting the diverse challenges of society. Educators and policymakers worldwide have called for more opportunities in the classroom for students to develop their creative abilities; for example, recent Asian educational reforms "infuse" creative elements into regular classrooms, resulting in improvements in students' attitudes, conceptions, abilities and behaviors in creative development (Cheng, 2011). However, United States educational systems have been relatively slow to adopt these initiatives in schools (Beghetto, 2010).

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A "big picture" view of creativity has emerged by consensus around the "4P's:" the *p*erson, the *p*rocess, the *p*roduct, and the "*p*ress" or environmental influence (Batey, 2012; Rhodes, 1961, 1987). In this view, creativity is not something that one either does or does not possess; rather, all individuals are capable of demonstrating creativity to some degree (Cropley, 2001; Rhodes, 1961; Sternberg and Lubart, 1995). For instructional purposes, the "creative process" approach emphasizes the *ways* in which creative products are produced (Finke, Smith, & Ward, 1992; Lubart, 2001) rather than the products themselves. There is also an emerging consensus about the stages in the creative process, including problem finding, idea generation, implementation, and evaluation (as described in Howard, Cully, & Dekoninck, 2008). However, an important questions remains: "Can creative thinking processes be taught, and what pedagogical elements will facilitate students' development?"

A review by Scott and colleagues (Scott, Leritz, & Mumford, 2004) found that well-designed creativity training programs produced significant gains in creative performance. Their quantitative meta-analysis of 70 prior studies found this training effect generalized across criteria, setting, and target populations. Further, the only approach found to be consistently effective was training that stressed the cognitive processing activities commonly held to underlie creative efforts. The authors concluded that instruction should emphasize the development of these cognitive skills and the heuristics involved in skill application (Scott et al., 2004). These results provide strong support that individuals can develop their creative process skills given the right learning experiences.

However, it is unclear whether and how learning experiences in college courses are aimed at developing students' creative process skills, and how these might differ based on discipline. One study identified 14 pedagogical elements appearing across 15 courses; common elements were open-ended projects and skill-building activities, and less frequently, risk taking and self-reflection (Daly, Mosyjowski, & Seifert, 2016). Another study explored how college faculty from six disciplines defined creativity within their fields (Marquis & Vajoczki, 2012). The study identified several factors as important across disciplines, most notably the generation of novel or original ideas and outcomes, along with challenging assumptions or conventions, problem solving, examination of phenomena from multiple points of view, and problem finding. In addition, there were discipline-specific trends; for example, faculty in the humanities most frequently identified challenging assumptions or conventions, the generation of detailed, elaborated ideas or outcomes, and expressiveness as the most important factors of creativity within their field. In contrast, the generation of multiple ideas or outcomes was the factor most commonly identified as important by engineering faculty. Health science faculty most frequently selected innovation and flexibility as key to creativity. These results support the notion that how instructors approach teaching about creative process may be at least partially discipline-specific (Marquis & Vajoczki, 2012).

Another study by Kazerounian and Foley (2007) explored the perceptions of instruction about creativity from instructors and students in Engineering, Science, and the Humanities. They identified ten maxims of creativity as instructional goals: 1) Keep an Open Mind, 2) Ambiguity is Good, 3) Iterative Process that Includes Idea Incubation, 4) Reward for Creativity, 5) Lead by Example, 6) Learning to Fail, 7) Encouraging Risk, 8) Search for Multiple Answers, 9) Internal Motivation, and 10) Ownership of Learning. Of these ten maxims, students reported all but one (Internal Motivation) as absent from the engineering curriculum (Kazerounian and Foley, 2007). Engineering also had the greatest degree of discrepancy between students and faculty reports; specifically, students valued creativity and felt that their instructors did not, while instructors reported that they also valued creativity, but did not see it in their students. The existence of this tension is also evident in a study that showed engineering students reported perceiving opportunities for creativity in their work, but they felt that the engineering curriculum limited their opportunities to pursue creativity (Tolbert & Daly, 2013).

In contrast, Kazerounian and Foley (2007) found students in the humanities felt only two of the ten maxims were missing from their curriculum (Ambiguity is Good and Learning to Fail), but both instructors and students valued creativity, and believed it was valued by the other group. In the sciences, the results fell in the middle, with 6 of 10 criteria reported absent in their courses by students. Science instructors and students reported they valued creativity, and students perceived their instructors as valuing creativity, but instructors did not see much creativity in their students. These findings revealed that while all three disciplines valued creativity, students and instructors often differ in their perceptions of its value to others.

Other studies of creative process skills have documented improvement in higher education courses. For example, in one study, engineering students listened to a lecture on creativity in the beginning of a course, and later took a creativity test and discussed their results. When compared to other students in the class, the students who received creativity education were found to be more innovative and creative (Cropley & Cropley, 2000). Another study examined a single course on advanced graphic design with a reputation as a "supportive classroom environment" for creativity (Cole, Sugioka, & Yamagata-Lynch, 1999). Four areas emerged as important characteristics for fostering creativity in this class: (1) building a personal teacher-student relationship, (2) lack of focus on assessment of creative work, (3) flexibility through openness and freedom of choice, and (4) in-classroom activities such as divergent thinking exercises. Another approach—groupwork intended to foster creativity—received mixed reviews. While enthusiasm was expressed for the multiple perspectives gained from small groups, the possibility of experiencing a "bad group" was reported as a disadvantage (Cole et al., 1999).

Surveys of students can reveal changes in their attitudes and performance based on aspects of pedagogy (Armbruster, Patel, Johnson, & Weiss, 2009). In a study of students in three different professional programs (business, higher education administration, and teacher education), students reported "freedom of expression, self-reflection, and thinking in new ways" as the aspects of instruction that helped them improve their creativity (Reynolds, Stevens, & West, 2013). Students also reported that creative projects helped in learning course content (Reynolds et al., 2013). Brazilian and Mexican students both reported that "lack of time or opportunity" was their most frequent obstacle to personal creativity (De Alencar, De Fleith, & Martinez, 2003). These studies suggest that students can report their experiences in courses they believe are

Table 1
Selected Courses, Discipline Categories, and Number of Student Participants in the Study.

Discipline	Course Title	Academic Unit	Participants
Arts	Dance Performance	Music, Theater, Dance	24
	Message Design	Art & Design	14
	Creative Process	Art & Design	44
Education	Advanced Videogames	Education	11
	Instructional Videogames	Education	49
	Simulations	Education	18
	Music Education	Music, Theater, Dance	11
Engineering	Interactive Technology	Engineering	22
	Product Design	Engineering	30
	Multidisciplinary Design	Engineering	12
	Video Gaming	Engineering	58
	Advanced Design	Engineering	24
	Materials Lab	Engineering	45
	Computing Systems	Engineering	54
Humanities	Screenwriting	Literature, Science, Arts	13
	Creative Writing	Literature, Science, Arts	27
	Technology	Literature, Science, Arts	9
Social Science	Psychology of Creativity	Literature, Science, Arts	32
	Science of Creativity	Literature, Science, Arts	14

helpful in developing their creative skills. This methodology has proven useful in identifying parents' and teachers' implicit understanding of creativity (Runco, Johnson, & Bear, 1993) and implicit theories of artistic, scientific, and everyday creativity (Runco & Bahleda, 1986).

It is likely that existing strategies for teaching creativity skills vary greatly by instructor and possibly across cultures, and most likely by discipline. Because the products of the creative process differ by discipline (a screenplay, a dance performance, a consumer product design, etc.), some researchers have argued that creativity is domain specific (Baer, 1991, 1998; Brown, 1989). Artists might be expected to develop creative processes that differ from those employed by writers and engineers. Other researchers have argued that creative process skills are generalizable across domains (Runco, 1984); for example, flexible thinking appears to be important to creativity, and studies have shown it is teachable (Chi, 1997; Runco & Okuda, 1991). Plucker and Beghetto (2004) point out that creative skills must be general at some level; otherwise, they would not transfer for use in other creative tasks even within a domain. Arguably, some aspects of creative processes will be domain-specific, and some domain-general (Plucker & Beghetto, 2004). To the extent that college instructors emphasize the domain specificity of skill application, their pedagogical methods about creative process are likely to differ by domain.

Currently, there is little available evidence about existing practices in instruction about creative process in college classrooms, especially across disciplines such as the arts, humanities, sciences, and engineering. A comparison would provide new knowledge about successful pedagogical elements for creative process instruction. Comparisons may also suggest opportunities where effective learning experiences might be shared across disciplines to enhance outcomes. The present study addresses this need by exploring creative process instruction in multiple courses across disciplines within a single university. The study addresses the question, "How do experiences in college courses incorporate opportunities to learn about creative process?"

2. Method

2.1. Participants

The courses in the study were offered at a large midwestern public university with a reputation for strong academic programs across a variety of disciplines. Of the more than 40,000 students (in the undergraduate, graduate, and professional schools) enrolled at this University, nearly 65% are undergraduate students and slightly less than half are female. Using a convenience sampling approach based on referrals by deans, instructors, and instructional development staff, twenty courses were selected with an emphasis in developing creative skills. All of the courses allowed undergraduate enrollment, although some also included graduate students. The classes represented curricula across five different disciplines within the university, including the Arts, Education, Engineering, Humanities, and Social Science (see Table 1). The number of courses included in each group ranged from two to seven, and the number of students differed by class. While each class is not necessarily representative of its discipline, the courses selected represent a diverse range of perspectives from a variety of subject areas. Interestingly, many of the courses identified also spanned traditional disciplinary boundaries. Nineteen of the twenty instructors recruited agreed to administer the survey as requested during a class session at the end of the term. All of the students present in class on the survey day agreed to complete it, resulting in 467 participants.

2.2. Materials

The survey included measures assessed with separate questions intended to elicit students' own views of the course experience and its relationship to their creative skills development. These first two questions asked students to describe their views of "creative process," and these are not discussed further in this article. The remaining questions asked students to highlight which specific lessons, activities, assignments, and projects in the course had an impact on their personal creative development. Specifically, the survey questions asked students to report on (1) their rating of the degree to which their creative skills had developed during the course, or *Course Impact Rating*; (2) their choice of important experiences for their creative process within the course, or *Critical Experiences*, (3) their advice about how to improve instruction to address creative skill development, or *Suggested Changes*, and (4) the activities and assignments included in the course, or *Course Activities and Influence*. The survey questions included:

(1) *Course Impact Rating*: "How much do you think your creative process skills developed as a result of this course? Circle your answer on the scale from 1 to 7," with 1 indicating "not at all" and 7 indicating "very much."
(2) *Critical Experiences*: "Please list three projects/activities/lectures/assignments, etc. from this course that you think most impacted your creative process skills. Please also explain why and how they affected your skill development."
(3) *Suggested Changes*: "What advice do you have about adding to the course to boost your skills in creative process? What elements did you feel were missing, and why do you think they would have helped? If anything were possible, what could be added to really influence your knowledge of creative process?"
(4) *Course Activities* and *Influence*: "From the list below, please indicate if you participated in the activity in this course, and rate how you believe it influenced the development of your creative process skills." A list of thirty-one course activities was provided. Participants indicated "Yes" or "No" for participation in each activity within the course, and then rated each activity on a 5-point Likert scale (Likert, 1931) based on how it influenced their skills, from 1 "not at all" to 5 "very much."

2.3. Procedure

In the last two weeks of the course, instructors chose a class session for distribution of the survey to all of their students in attendance. The following instructions given were: "As part of this course, you have participated in a variety of experiences that have the potential to influence your approach to being 'creative.' The skills you apply to many of the types of problems in this course can be called your 'creative process' skills. We are interested in how you believe this course may have impacted the development of your creative process skills. You may choose to skip any question you wish." Administration of the survey took less than 20 min to complete within each class.

2.4. Analysis

Each survey question was considered separately, and coding schemes developed for the open-ended questions. *Critical Experiences* were grouped as falling into one or more of eighteen (plus "other") types of experiences listed as shown in Table 2, which also included reasons students cited for the value of these experiences. *Suggested Changes* were scored as falling into one or more of twenty-seven categories, as shown in Table 3. The same approach to coding was applied separately to each question for consistency. First, an independent coder read through all students' responses to each question and scored the response from each participant as an entirety using a coding scheme. The coding scheme for each question included an initial set of categories developed in advance, and was refined and expanded as needed based on observed responses. A second coder independently scored the responses, and inter-rater reliability using Cohen's Kappa ranged from 0.82 to 0.87, suggesting an acceptable level of agreement (Landis & Koch, 1977). Discrepancies in coding were resolved in each case by a third independent coder. All of the coders were undergraduate students, and all were blind to course names.

The quantitative data from *Course Impact Ratings* and *Course Activities and Influence* questions were analyzed using descriptive statistics.

The data from participants were combined across all courses and within disciplinary groups. Missing data (where the participant did not provide a response) were not included in averages. To protect the confidentiality of participating instructors, no individual courses are identified with their results.

3. Results

Major findings are summarized across all courses and within the five disciplinary course groups (the Arts, Education, Engineering, Humanities, and Social Science). By combining courses into their disciplinary homes, pedagogic trends based on similarities in course content may emerge. For example, courses designed to address creative skills in Engineering may produce different experiences for students than those in the Arts.

Table 2
Conceptual Themes Used in Coding Critical Experiences.

Theme	Example of Participants' Reasons for Reporting a Critical Experience
Critique	"Critique. It was a chance to compare my thoughts to other people's and learn from what they came up with."
Discussion	"Definitely for me personally, was a very lucrative time! Collaborating on ideas with the other students was amazing– encouraged me to really listen rather than focus on my own ideas–definitely rewarding!"
Exam	"I have to think of ways to solve problems."
Group work	"At the group project level you have individuals that don't complete their work and cannot agree on a design so fronting this project has made me develop as a leader."
Guest speaker	"A professor's recital exhibited synergy and appeal that I took away."
Homework	"The homework didn't specify what game/program to write, but had list of things that should be included in the program. This allowed me to come up with my own creative thing using the resources I had."
Idea generation	"I learned more efficient way to come up with ideas."
In-class exercise	"This task has been attempted by people all over the world, yet we still had to compete by being creative. Although my group failed, the experience was exciting and inspiring."
Interdisciplinary activity	"The project was a challenge because it was a new medium. I was able to learn so much that I was not capable of before this class."
Iteration	"Had to put a new own twist on something already created and set in stone so to say."
Lab experiment	"Gave us the opportunity to work on lab project that we wanted to do. Gave us time to do our own research. Overall, positive impact because I care more about a lab that I design."
Making	"I learned the importance in making whether they work or not but making is important to prove the point either way."
Open-ended project	"It gave me a process, prior to this class I wouldn't think of problems as things I should fix, unless it was assigned. Now I have the knowledge I can solve the problems & have the motivation to do so."
Presentations	"It helped me prepare for work environment way to convey knowledge."
Reading or movie	"Thinking, feeling like a gamer. Experiencing what a gamer experiences. About taking perspectives."
Real examples	"Exposure to lectures about space sciences not typically introduced to mech. engineers allows the creative process to start thinking outside-the-box for problem solving and looking at how others accomplished this."
Reflection	"I learned about my own process and how terrible I am at time management."
Technical training	"It was awesome fitting a product to a unique business plan and trying to make it work."

Table 3
Themes Used to Code 'Suggested Changes to Courses'.

Do closer analysis	Getting feedback	Learn to be open to failure
Emphasize the unique	Learn across disciplines	Learning basics
Less lecturing	More exercises	More practice
Less memorization	More explanation	More prototyping
Less research	More freedom	More revision
Meet more	More group work	More structure
More brainstorming	More hands-on	More time
More discussion	More in-depth	Push me more
More examples	More lectures	Workshopping

3.1. Course impact ratings

Students first gave an estimate of how much they felt their creative process skills developed as a result of their course. The average impact rating across all of the courses in the study was 4.6 (SD = 1.49) on a seven-point scale, indicating that students perceived their classes as having a moderately high impact on their creative skill development.

The discipline groups differed in their ratings of course impact, $F(4, 498) = 20.64$, $p < 0.001$, $\omega p^2 = 0.14$. Post hoc comparisons using the Bonferroni correction revealed two distinct groups: 1) Engineering and Education, and 2) Humanities, Social Science, and the Arts, where each course was statistically different from those in the other group ($p < 0.05$). Engineering classes had the lowest impact rating (M = 4.1, SD = 1.52), with students indicating that their skills were "somewhat" changed on average. Education students also rated their skills as "somewhat" changed (M = 4.5, SD = 1.38). The two fields traditionally identified as "creative," the Arts (M = 5.5, SD = 1.48) and the Humanities (M = 5.3, SD = 1.16), received the highest impact ratings among the disciplines, along with Social Science (M = 5.2, SD = 1.03). Humanities and Arts classes might be expected to receive high scores on course impact because of their emphasis on the practice of writing and artistic execution. The two highest course ratings (both 5.9) were in the Humanities and in the Arts, and the two lowest were in Engineering. The lower-rated engineering course group also had the largest range in ratings, from 2.89 to 5.75.

Students also wrote open-ended responses with the reasons for their overall ratings. Considering themes reported by 10% or more of students within each disciplines, the most frequently cited reasons for the ratings given were self-perceived changes in their own creative processes related to *being more open* (25%), *increasing understanding* (23%), *seeing others' perspectives* (19%), and *increasing openness to failure* (18%). This suggests students appreciated changes in their own openness and understanding as a result of the course experience, and felt it had an important impact on their skill development. Students' comments also demonstrated an increased comfort with their own creative development:

> "It made my creativity more critical. It's instilled the importance of taking a creative artifact, such as a script, and tweaking it and not being afraid to change, alter, manipulate, the final product. Taught me to let go of scenes, imagery, characterize, that don't work in portraying your message, despite how difficult it may be." (Humanities student)

> "It forced me to be honest with myself and encouraged me to let my pieces go where they needed to go, not where I originally thought they should go." (Arts student)

> "Well, we thought a lot about creativity. Looking at it as a science makes me feel like anyone can achieve it–even me!" (Social Science student)

> "I think the fact that I realized that the creative process is composed of several steps allowed me to be more creative. Previously, I thought I had to just think of something and then create it, but I now know the steps in between, which helps exponentially with planning, etc." (Social Science student)

This suggests it is possible to enhance creative skills outside the traditional practice of creating works of art; in addition, understanding theories and research on the creative process can be helpful.

While the Education and Engineering students rated their courses significantly lower for their impact on creative skill development, students still reported some gains in their creative process skills. The Education courses included approaches seen less often in other courses. Specifically, education courses emphasized *perspective taking* as a component of creativity, along with systematic exposure to existing work in the field. Comments from Education students reflect these emphases:

> "This course had an impact on my process because it made me look at situations from different perspectives and I had to think of my goals while facing consequences at the same time." (Education student)

> "I think our courses deals more with evaluating other peoples' creative process but at the same time that enhances our own creative process." (Education student)

Students in Engineering courses commented on design experiences as outlets to exercise their creative processes:

> "I was pushed to design a unique game with an interface that could be used with only one button. On top of that there had to be level design such that levels increased in difficulty. The menu system had to be user friendly. Also, the game needed to be able to be played by patients. All these challenges led to the creation of a truly unique game." (Engineering Student)

> "This is the first time I have confronted a design problem not already having an enforced method and 'correct' solution – forced to consider a design as a system of problems, causes, & perspectives of different people – forced to consider solutions with side effects, limitations, & realistic results." (Engineering Student)

As a summative measure, students' ratings best capture how much they perceived their creative process skills changed as a result of their course. Since all five groups averaged over the scale midpoint of 3.5, students in each of the disciplinary course groups reported a positive change in creative skill development as a result of their courses.

3.2. Critical experiences

Students wrote about specific episodes they viewed as important to their creative development (up to 3, with an average of 1.7 offered by students). The subjects reported a total of 842 different experiences as critical to their creative process development. The frequency of each category of experience appears in Fig. 1, with the categories ordered by average frequency from highest to lowest. The highest percentages of experiences in all groups occurred in the categories most frequent overall (shown starting on the left side of the figure). The most frequent categories across disciplines included *technical knowledge* (35%), *in-class exercises* (30%), *reading or movies* (23%), and *group work* (20%).

While a decreasing trend is observable in all five groups, specific critical experiences reported are different across disciplines. Arts students reported *technical training* and *group work* as critical experiences; of note, 55% of the Arts students reported critical experiences in technical training, compared to 42% of engineering students. Education students uniquely mentioned *exam* experiences as critical, and also frequently included *homework* and *technical training* experiences. Engineering students most frequently cited *technical training, group work,* and *lab experiments* as most critical to their creative development. Humanities students listed *in-class exercises* much more often than the other class groups, and frequently mentioned *reading or movies* and *group work*. Social Science students included *homework* and *discussion* more than other class groups, and also frequently mentioned *in-class exercises* and *reading or movies.*

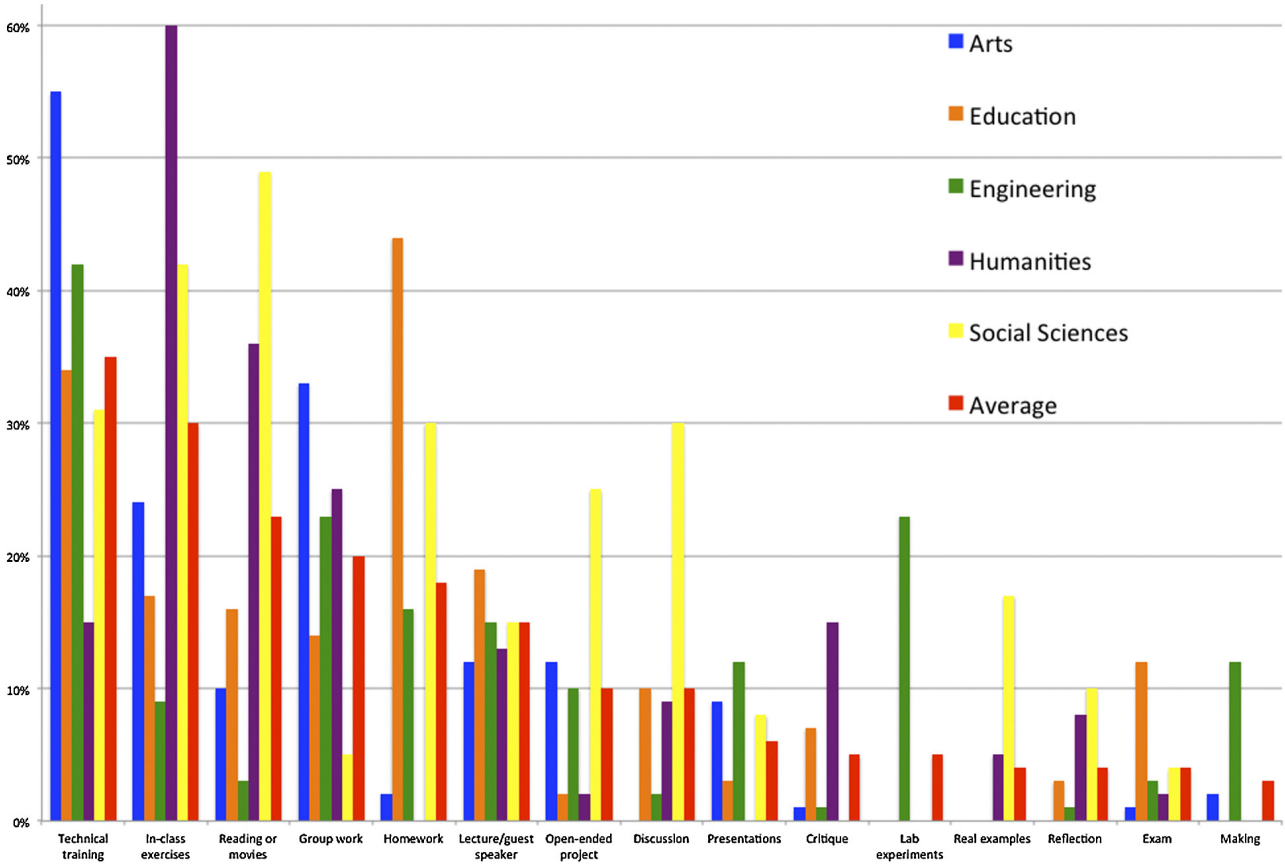

Fig. 1. Percentage of college students' reported *Critical Experiences* coded by discipline and ordered by averaged frequency. The observed percentages in each group suggest shared experiences across disciplines in the left-hand categories.

In sum, patterns of experiences were similar overall between groups, but notable differences in types of critical experiences occurred.

3.3. Suggested changes

To the open-ended question about suggested changes for their course to improve students' creativity development, students added 352 suggestions on how to improve their course's impact on their creative skill development. The response rate for this open-ended question ranged from 8% to 33% of each class. The frequencies of changes mentioned by category are shown in Fig. 2. The most frequent suggested changes across courses were *more groupwork, more time*, and *more freedom*, followed by *more exercises* and *more hands-on* activities. The suggested changes that emerged from the responses were compiled to determine the number of different courses where each suggestion occurred. *More freedom* was mentioned in 58% of the 19 classes, *more group work* by 47%, and *more time* by 42%. *Learning from other disciplines* was mentioned by 31% of the classes, and *more exercises* and *more hands-on activities* by 26%. The other categories were mentioned in 3 or fewer classes, with the majority of suggestions mentioned by just one class. By discipline, the most frequent suggestions included *getting feedback* in the Arts (67%), *more brainstorming* in Education (67%), *more in depth* and *more structure* in Engineering (28%), *closer analysis* in the Humanities (67%), and *more practice* and *more examples* in Social Science (50%).

In sum, across disciplines, students seemed to emphasize suggested changes involving more opportunities to *practice* their creative process through activities.

3.4. Course activities and influence

Students reported most of these activities listed on the survey as occurring often in their courses. Twenty-six of the 31 activities listed were cited by over half of all students, indicating a great deal of overlap in activities across classes. The percentages of students reporting each course activity are shown in Table 4. *Instructor feedback* was cited by over 80% of all students (though less frequent in Engineering classes) as having an influence on the development of creative process skills, as was *brainstorming creative ideas*. Activities frequently reported with high agreement across disciplinary groups also included *having your creative ideas critiqued, working with teams*, and *hearing lectures*. The course activities with the largest disparities

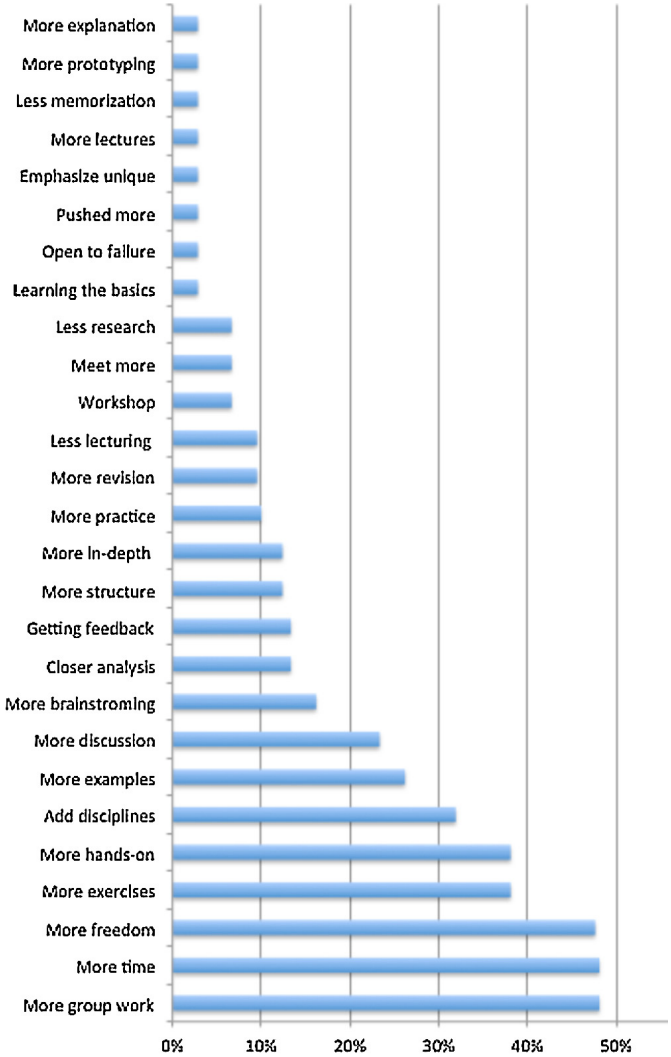

Fig. 2. Percentage of students' responses to *Suggested Changes* coded in categories ordered by frequency.

among disciplinary groups included *discussing research on creative process* (in Social Science and Education groups), *creative writing* (in Humanities, Social Science, and Education), *discussing case studies* and *writing reflectively about your creative process* (in Social Science), *and discussing your creative process* (in Arts and Social Science).

Students rated the degree to which these course activities influenced their creative process skills on a five-point Likert scale. The average influence ratings by discipline for the course activities are indicated in Table 7 as "high influence" (average rating 4 or higher on the 5 point scale), or "low influence" (average rating under 3). All of the activities (except *aptitude tests, instructional media*, and *creative writing*, which occurred infrequently across classes) received influence ratings between 3.0 and 4.0 when averaged across disciplines, suggesting that most of these activities were viewed as helpful in creative skill development. The average influence rating on the five-point scale was 3.4 (SD = 0.35), suggesting students found the course activities overall to be of moderate influence on their creative processes.

Four disciplines (with the exception of Engineering) rated *receiving instructor feedback* as highly influential. Other activities with high-influence ratings in two of the five groups included *learning from professionals* (Humanities and Social Science), *choosing project topics* (Humanities and Social Science), *open-ended projects* (Education and Arts), and *receiving critiques* (Humanities and Arts). Engineering students did not rate any activities as highly influential, averaging lower than 4.0 for all activities, while Humanities students rated 12 different activities as high impact (over 4.0). Social Science students cited *receiving feedback from instructor* and *choosing your own project topic* as highly influential, and Education students also mentioned *receiving feedback from instructor* and *open-ended projects. Arts* students alone reported *writing reflectively* and *a new discipline or context* as high influence activities in their courses.

The influence ratings of activities were correlated with the frequency of their occurrence, $r(30) = 0.336$, $p < 0.01$. For example, *receiving instructor feedback* was both frequent and influential (4.2), as was *choosing your project topic* (3.9), *open-ended projects* (3.8), and *learning from professionals* (3.8). *Brainstorming* was a very frequent activity across courses, but while

Table 4
Frequency of Course Activities and their Influence Ratings by Discipline.

Course Activity	Engineering	Humanities	Social Science	Education	Arts	Average
Instructor feedback	61	84*	96*	98*	78*	83*
Brainstorming	76	79*	88	73−	82−	79
Choosing projects	57	76*	94*	78	53	72
Build technical skill	83	67*	67	56	71	71
Seeing professionals	63	67*	85*	68	79	70
Seeing examples	64	69*	85	75	60	69
Open-ended projects	51	64	78	85*	71*	69
Engaging in endeavor	69	83*	81	46−	67−	69
Receiving critiques	60	73*	77	72	62*	69
Defining a problem	70	47	72−	85	53	68
Lectures on process	58	64	76	77	65−	66
Presenting ideas	66	48	88	57	67	65
Critiquing peers	55	53	85	79	74	64
Practicing activity	46	66*	78	54	74	61
Reading research	46−	44	99	68	39−	59
Working in teams	69	53	59−	54	48	59
Case studies	52−	59*	85	81	33−	58
Learning strategies	54	50	78	50	58	56
Real-world problems	62	45−	62	75−	32	56
Reading articles	36−	73	94	71	48−	54
Writing reflectively	37−	57	92	49	66*	54
Building artifacts	53	66*	46	30	62	53
Try new discipline	47	49	55	48−	73*	53
Creative writing	31−	73	72−	81	33−	52−
Discussing process	47	48	90	66	75	52
Critiquing experts	43	57*	73−	74	35−	52
Diverse teams	52	35−	62−	48	50	50
Risk taking	34	45	35−	35	70	42*
Imaginative exercises	47−	37	64−	42	47	40*
Instructional media	57	28	19−	38	25−	39−
Aptitude tests	34−	15	46−	9%−	6%−	23−

Note: Values indicate the percentage of students who reported the activity in their course.
− = Average Influence Rating below 3.0 (not influential).
* = Average Influence Rating 4.0–5 (highly influential).

viewed as highly influential in the Humanities, it was of low influence in the Arts and Education. However, some activities reported as having a high influence occurred in fewer courses, such as *practicing a creative activity* (3.7), *writing reflectively* (3.5), *creating in a new discipline or context* (3.5) and *case studies* (3.4). These activities were rated above 3.0 on the 5-point scale, indicating students found them to have a moderate influence on their creative skills; however, they were not listed by as many students. On the other hand, *critiquing peers' ideas* was reported frequently (70%), but was not rated as highly influential (3.3). The activities *instructional media* (2.6) and *creative writing* (2.9) were rated across disciplines as having the least influence on the creative process (rated below 3.0 on average on the 5-point scale).

In sum, across disciplines, most of the listed course activities were reported to be both frequent and very influential in creative process development.

4. Discussion

4.1. Summary of findings across disciplines

From these data, a picture emerges of general trends in students' views of the creative process following their course instruction. Course impact ratings were moderately high over all disciplines, but higher in the Arts, Humanities, and Social Science classes. Students across disciplines reported critical experiences centered on technical information, and on in-class, homework, and group exercises. Students across disciplines also shared suggestions for more time, freedom, and group work, along with more interaction across disciplines. Finally, course activities were often shared in common across disciplines, as were the activities rated as most influential to the development of students' creative process skills. These activities included instructor feedback and critiques, brainstorming ideas (Osborn, 1953), learning from professionals and others' work, open-ended projects and choosing projects, and building technical skills. While unique emphases appeared within each discipline, the main finding apparent from these results is the high degree of commonality in creative process pedagogy across disciplines.

These findings may appear surprising because the techniques involved in executing creative works differ greatly by discipline; for example, writing a screenplay, choreographing a dance, and building a ball-balancing platform involve very different skills in execution. However, students' responses did not stress these types of domain-specific skills as important

learning experiences for their creative process skills. Rather, students across disciplines described similar pedagogical tools as enhancing the development of their creative process skills.

Across disciplines, an important theme in these findings is the opportunity to receive feedback on creative efforts. The students emphasized instructor feedback, as well as opportunities to give and receive peer critiques, and time for working in groups. Students appeared to find the reactions of others to their creative work to be an important ingredient in developing their creative skills. In many college classrooms, meeting time with an instructor is set to 3 or 4 h (or less) per week; however, in art schools, studio time with instructors is often six hours per week or more. This theme suggests adding work within the classroom with other students and the instructor present for more time each week in order to foster creative skill development.

The practice of engaging in creative work as a way of learning about creative process is another important theme reported by students. The suggested changes emphasized hands-on activities, exercises, and group work, along with more time on projects (as seen in the emphasis on brainstorming creative ideas, choosing project topics and working on open-ended projects). Students also saw building technical skills as a critical activity in courses, especially in disciplines like Art, Engineering, and the Humanities (writing courses).

4.2. Summary of findings comparing disciplines

Despite the evident commonalities between disciplines, some differences in instruction by discipline are worth noting. Instruction on creative process in the Arts is often presumed to be the gold standard in pedagogy on creative process. These results show students in Arts courses uniquely endorsed writing reflectively, along with working in a new discipline or context, as influential activities. This suggests Arts courses were able to engage students in thinking about their own creative process, along with attempting to be creative in new contexts. The Arts group also cited *group work* more often as a frequent source of influential experiences. In addition, some courses in the study combined technology with traditional disciplines (the Humanities and Education), or combined two disciplines (Arts and Engineering), resulting in a broadened perspective. Students also suggested incorporating multiple disciplines in the courses of study within their fields. It may be that learning about creative process benefits from experiencing activities in multiple disciplines; if so, an interdisciplinary setting with a strong experiential emphasis would be helpful (Fixson, 2009).

Education students gave lower ratings of course impact on the development of their creative processes. These courses may differ because they focused on existing systems that deliver educational content to high school students and other learners in innovative ways. As a result, course emphases may be on evaluating the impact of creative applications on instruction, and less on the creation of new instructional methods. Education students reported less group work and in-class exercises than other disciplines, and more homework and exams. The learning experiences in Education courses included two uncommon practices, perspective taking and building of a repertoire of work in the field that may be of value in other disciplines.

Engineering students reported a lower impact of their courses on their creative process skills compared to the other disciplines. Engineering students cited technical training as the most important experience, and they were the only group in which receiving feedback from instructors occurred infrequently, and was viewed as less influential. Standards for undergraduate education in Engineering explicitly include the “development of student creativity” (ABET Board of Directors, 2011); however, prior studies have also found that Engineering students struggle with creativity (Kazerounian & Foley, 2007; Authors, 2014; Ahmed, Wallace, & Blessing, 2003; Ball, Evans, & Dennis, 1994; Cross, 2001; Tolbert & Daly, 2013), and may view themselves as less creative (Court, 1998). Engineering instructors may be less likely to speak about “creative process” skills (calling them “design” instead) (Daly, Mosyjowski, & Seifert, 2014), and may find it difficult to teach students how to think innovatively (Grasso, Burkins, Helble, & Martinelli, 2008; Klukken, Parsons, & Columbus, 1997; Pappas & Pappas, 2003; Richards, 1998).

Humanities students gave their courses a high rating for developing on their creative process, and considered the majority of their course activities as highly influential for their creative process. Humanities courses reported more in-depth exploration of topics, and a greater influence of in-class experiences in students’ development of creative skills. Social Science students also rated their courses as helpful for their creative processes. Social Science students mentioned less common activities like reading about theories and research on creative process as important. The students’ perception of Social Science courses as highly impactful on their creative process suggests that the application area is less important than the pedagogical tools in facilitating students’ growth.

4.3. Implications

Our findings parallel previous results showing the importance of a “supportive classroom environment” for creativity (Bull, Montgomery, & Baloche, 1995; Cole et al., 1999; Light, 2002). Students in our study echoed this theme in the form of openness, flexibility, and freedom of choice. Other similarities to prior findings include students’ stated needs for more time and opportunities for creative growth (De Alencar et al., 2003). The cross-course commonalities students reported in our study included choosing your own project, open-ended projects, and group work. Prior studies support that open-ended projects or assignments can be an effective technique for creativity instructors (Horng, Hong, ChanLin, Chang, & Chu, 2005). However, to optimize open-ended projects for creative skill development, incorporating scaffolding and reflection is important (Prince & Felder, 2006). A meta-analysis of the effectiveness of active learning projects in engineering show

broad support (Prince, 2004), and group projects have shown substantial benefits over lecture and discussion formats in both engineering and the liberal arts (Colbeck, Campbell, & Bjorkland, 2000; Terenzini, Cabrera, Colbeck, Parente, & Bjorkland, 2001; Tsui, 1999). Open-ended group projects may facilitate problem solving, and this link to creative thinking may lie behind students' preferences (Hauer & Daniels, 2008).

These findings together suggest ways to support the development of creative skills. Student perceptions of helpful pedagogy about the creative process focus on practice-based, cooperative, and open-ended qualities. Students recommend more practice of creative tasks, including more time, more group work, and more freedom to work on open-ended projects across all disciplines. In addition, students in our study showed agreement (except Engineers) that receiving feedback from instructors was both frequent and influential. Students' perceptions of feedback indicate that it enhances learning beyond the individual course (Poulos & Mahony, 2008). The present findings suggest methods for enhancing creative learning experiences in the classroom across disciplines.

Finally, the results suggest some pedagogical tools that have a high impact on students but are not as common across courses. For example, exposure to a corpus of creative work helps to build a repertoire within a field (Schön, 1990):

> "Just as we might imagine a designer of social service systems having access to a repertoire of metaphors from which he can generate problem-setting stories, so we can imagine a graphic designer having access to a repertoire of visual images any one of which can serve as a basis for the representation of a design situation." (p. 134)

Repertoire building appears less common, or even non-existent, in some disciplines; however, it can be a powerful tool as models for successful outcomes, and can inspire students' own creative work.

Course activities such as seeing examples of professionals' creative work, lectures, student presentations, discussions, and reading help to identify a body of work within a creative discipline. Students frequently cited these features as facilitating their own creative process skills. Less frequently mentioned was self-reflection, though writing reflectively was noted as highly influential in arts classes. Prior studies have noted reflection as helpful in creative process training (Adams, Turns, & Atman, 2003; Schön, 1983; Treffinger et al., 2002).

4.4. Limitations

These results should be considered in light of the limitations in the study. First, the present study examined instruction within a single Midwestern university much larger than most institutions of higher education, and may also reflect instruction and student interests specific to American schools (e.g., De Alencar et al., 2003). Helpful comparisons in pedagogical practices may be available in specialized schools aimed at training creative practitioners, such as art schools and conservatories (Kuhn, 2001). In addition, this study included only a small sample of classes within each of five disciplines, and may not represent how creativity is taught and perceived more broadly within each discipline. Because there is little empirical evidence or accepted standards about how to foster creative skills in college students, open-ended questions allowed collection of data about what students across disciplines think about their course experiences involving creativity. Asking students to describe which instructional activities they view as helpful is a first step in understanding what takes place in creative process education in classrooms across disciplines.

It is important to note that the data reported were solely self-reports of students based on their experiences in the courses. No information on instructor goals or course materials was included in this study. In addition, this study did not attempt to assess creative skills as an individual difference (Runco, 1984; Sternberg & Lubart, 1995). The study used a single time point – the end of the course – to gather student responses. As a result, it may capture student self-selection into disciplines and courses rather than differences in course experiences. Finally, the validity of instruction on creative process is not evaluated through outcome measures of students' creative performances in the course, nor in their endeavors following the course. Ideally, the elements of instruction would be tied to measures of benefit in future creative practice. For example, a study of artists' problem finding during art school was tied to later outcomes such as sales of their work (Getzels & Csikszentmihalyi, 1976). In the present study, as with most studies of educational practice, there is no evidence collected to support the impact of instruction on performance later in life.

4.5. Conclusion

As the most extensive study of students' perceptions of creative learning experiences in higher education to date, these findings provide many suggestions about how courses can facilitate creative skill development. From the study, it is clear that there are common approaches to instruction on creative process across disciplines. Students reported a high degree of overlap in course activities, along with a positive impact of instruction on their creative process skills. These results provide a summary of pedagogical elements thought to enhance creative process skills as described by students. By examining the nature of instruction in these high quality college courses, the nature of successful learning experiences about creative process becomes more evident. Further research is needed to identify the relationship of these learning experiences to students' creative performance outcomes.

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References

ABET Board of Directors. (2011). *2011–2012 Criteria for accrediting engineering programs*.. Retrieved August 30, 2011, from http://www.abet.org/forms.shtml

Adams, R. S., Turns, J., & Atman, C. J. (2003). Educating effective engineering designers: The role of reflective practice. *Design Studies*, *24*, 275–294.

Ahmed, S., Wallace, K. M., & Blessing, L. T. M. (2003). Understanding the differences between how novice and experienced designers approach design tasks. *Journal of Research in Engineering Design*, *14*(1), 1–11.

Armbruster, P., Patel, M., Johnson, E., & Weiss, M. (2009). Active learning and student-centered pedagogy improve student attitudes and performance in introductory biology. *CBE-Life Sciences Education*, *8*(3), 203–213.

Daly, S. R., Mosyjowski, E., & Seifert, C. M. (2014). Creativity education in engineering courses. *Journal of Engineering Education*, *103*(3), 417–449.

Baer, J. (1991). Review of creativity across performance domains. *Creativity Research Journal*, *4*, 23–39.

Baer, J. (1998). The case for domain specificity of creativity. *Creativity Research Journal*, *11*, 173–177.

Batey, M. (2012). The measurement of creativity: From definitional consensus to the introduction of a new heuristic framework. *Creativity Research Journal*, *24*(1), 55–65.

Ball, L., Evans, J., & Dennis, I. (1994). Cognitive processes in engineering design: A longitudinal study. *Ergonomics*, *37*(11), 1753–1786.

Beghetto, R. A. (2010). Creativity in the classroom. In J. C. Kaufman, & R. J. Sternberg (Eds.), *Cambridge handbook of creativity* (pp. 447–463). Cambridge: Cambridge University Press.

Brown, R. T. (1989). Creativity: What are we to measure? In J. A. Glover, R. R. Ronning, & C. R. Reynolds (Eds.), *Handbook of creativity* (pp. 3–32). New York: Plenum Press.

Bull, K. S., Montgomery, D., & Baloche, L. (1995). Teaching creativity at the college level: A synthesis of curricular components perceived as important by instructors. *Creativity Research Journal*, *8*(1), 83–89. http://dx.doi.org/10.1207/s15326934crj0801

Cheng, V. Y. (2011). Infusing creativity into Eastern classrooms: Evaluations from student perspectives. *Thinking Skills And Creativity*, *6*(1), 67–87. http://dx.doi.org/10.1016/j.tsc.2010.05.001

Chi, M. T. H. (1997). Creativity: Shifting across ontological categories flexibly. In T. B. Ward, S. M. Smith, & J. Vaid (Eds.), *Creative thought: An investigation of conceptual structures and processes* (pp. 209–234). Washington, DC: American Psychological Association.

Colbeck, C. L., Campbell, S. E., & Bjorklund, S. A. (2000). Grouping in the dark: What college students learn from group projects. *Journal of Higher Education*, *71*(1), 60–83.

Cole, D. G., Sugioka, H. L., & Yamagata-Lynch, L. C. (1999). Supportive classroom environments for creativity in higher education. *Journal of Creative Behavior*, *33*(4), 277–293.

Court, A. W. (1998). Improving creativity in engineering design education. *European Journal of Engineering Education*, *23*(2), 141–154.

Cropley, A. J. (2001). *Creativity in education and learning: A guide for teachers and educators*. London, UK: Kogan Page.

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

Cross, N. (2001). Design cognition: Results from protocol and other empirical studies of design activity. In C. M. Eastman, W. M. McCracken, & W. C. Newstetter (Eds.), *Design knowing and learning: Cognition in design education* (pp. 79–104). Amsterdam: Elsevier.

De Alencar, E. M. L. S., De Fleith, D. S., & Martinez, A. M. (2003). Obstacles to personal creativity between Brazilian and Mexican university students: A comparative study. *Journal of Creative Behavior*, *37*, 179–192. http://dx.doi.org/10.1002/j.2162-6057.2003.tb00832.x

Finke, R. A., Ward, T. B., & Smith, S. M. (1992). *Creative cognition: Theory, research, and applications*. Cambridge, MA: MIT Press.

Fixson, S. K. (2009). Teaching innovation through interdisciplinary courses and programmes in product design and development: An analysis at 16 US schools. *Creativity and Innovation Management*, *18*(3), 199–208.

Getzels, J. W., & Csikszentmihalyi, M. (1976). *The creative vision: A longitudinal study of problem finding in art*. New York: Wiley.

Grasso, D., Burkins, M. B., Helble, J., & Martinelli, D. (2008). Dispelling the myths of holistic engineering. *PE Magazine*, 27–28.

Harvard Business School Press. (2003). *Harvard business essentials: Managing creativity and innovation*. Boston, MA: Author.

Hauer, A., & Daniels, M. (2008). A learning theory perspective on running open-ended group projects (OEGPs). *Proceedings of the tenth conference on australasian computing education* (Vol. 78) (pp. 85–91), 2008 January.

Horng, J., Hong, J., ChanLin, L., Chang, S., & Chu, H. (2005). Creative teachers and creative teaching strategies. *International Journal of Consumer Studies*, *29*(4), 352–358.

Howard, T. J., Culley, S. J., & Dekoninck, E. (2008). Describing the creative design process by the integration of engineering design and cognitive psychology literature. *Design Studies*, *29*, 160–180.

Kazerounian, K., & Foley, S. (2007). Barriers to creativity in engineering education: A study of instructors and students perceptions. *Journal of Mechanical Design*, *129*, 761–768.

Kirby, D. A. (2004). Entrepreneurship education: Can business schools meet the challenge? *Education+ Training*, *46*(8/9), 510–519.

Klukken, P. G., Parsons, J. R., & Columbus, P. J. (1997). The creative experience in engineering practice: Implications for engineering education. *Journal of Engineering Education*, *86*(2), 133–138.

Kuhn, S. (2001). Learning from the architecture studio: Implications for project-based pedagogy. *International Journal of Engineering Education*, *5*, 349–352.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics*, *33*, 159–174.

Light, G. (2002). From the personal to the public: Conceptions of creative writing in higher education. *Higher Education*, *43*(2), 257–276.

Likert, R. (1931). A technique for the measurement of attitudes. In *Archives of psychology*. New York: Columbia University Press.

Lubart, T. I. (2001). Models of the creative process: Past, present and future. *Creativity Research Journal*, *13*(3), 295–308.

Marquis, E., & Vajoczki, S. (2012). Creative differences: Teaching creativity across the disciplines. *International Journal for the Scholarship of Teaching and Learning*, *6*(1) [Article 6].

National Leadership Council for Liberal Education, & America's Promise. (2007). *College learning for the new global century*. Washington, D.C: Association of American Colleges and Universities. Retrieved from http://www.aacu.org/leap/documents/GlobalCentury_final.pdf (March 1, 2014)

Osborn, A. F. (1953). *Applied imagination*. New York: Scribners.

Pappas, J., & Pappas, E. (2003). Creative thinking, creative problem-solving, and inventive design in the engineering curriculum: A review. In *Proceedings of the 2003 American Society for Engineering Education Annual Conference*.

Plucker, J. A., & Beghetto, R. A. (2004). Why creativity is domain general, why it looks domain specific, and why the distinction does not matter. In R. J. Sternberg, E. L. Grigorenko, & J. L. Singer (Eds.), *Creativity: From potential to realization* (pp. 153–167). Washington, DC, US: American Psychological Association.
Poulos, A., & Mahony, M. J. (2008). Effectiveness of feedback: The students' perspective. *Assessment & Evaluation in Higher Education*, *33*(2), 143–154.
Prince, M. (2004). Does active learning work? A review of the research. *Journal of Engineering Education*, *93*, 223–232.
Prince, M. J., & Felder, R. M. (2006). Inductive teaching and learning methods: Definitions, comparisons, and research bases. *Journal of Engineering Education*, *95*(2), 123.
Reynolds, C., Stevens, D. D., & West, E. (2013). I'm in a professional school! Why are you making me do this? A cross-disciplinary study of the use of creative classroom projects on student learning. *College Teaching*, *61*(2), 51–59.
Rhodes, M. (1961). An analysis of creativity. *The Phi Delta Kappan*, *42*(7), 305–310.
Rhodes, M. (1987). An analysis of creativity. In S. G. Isaksen (Ed.), *Frontiers of creativity research: Beyond the basics* (pp. 216–222). Buffalo, NY: Bearly.
Richards, G. (1998). Stimulating creativity: Teaching engineers to be innovators. *Proceedings of the Frontiers in Education Conference*, 1034–1039.
Runco, M. A. (1984). Teachers' judgments of creativity and social validation of divergent thinking tests. *Perceptual and Motor Skills*, *59*, 711–717.
Runco, M. A., & Bahleda, M. D. (1986). Implicit theories of artistic, scientific, and everyday creativity. *The Journal of Creative Behavior*, *20*(2), 93–98.
Runco, M. A., Johnson, D. J., & Bear, P. K. (1993). Parents' and teachers' implicit theories of children's creativity. *Child Study Journal*, *23*, 91–113.
Runco, M. A., & Okuda, S. M. (1991). The instructional enhancement of the flexibility and originality scores of divergent thinking tests. *Applied Cognitive Psychology*, *5*(5), 435–441.
Schön, D. A. (1983). . *The reflective practitioner: How professionals think in action* (Vol. 5126) New York: Basic Books.
Schön, D. A. (1990). The design process. In V. A. Howard (Ed.), *Varieties of thinking: Essays from Harvard's philosophy of education research center* (pp. 110–141). New York: Routledge.
Scott, G., Leritz, L. E., & Mumford, M. D. (2004). The effectiveness of creativity training: A quantitative review. *Creativity Research Journal*, *16*(4), 361–388.
Sternberg, R. J., & Lubart, T. I. (1995). *Defying the crowd: Cultivating creativity in a culture of conformity*. New York: Free Press.
Terenzini, P. T., Cabrera, A. F., Colbeck, C. L., Parente, J. M., & Bjorkland, S. A. (2001). Collaborative learning vs. lecture/discussion: Students' reported learning gains. *Journal of Engineering Education*, *90*(1), 123–130.
Tolbert, D. A., & Daly, S. R. (2013). First-year engineering student perceptions of creative opportunities in design. *International Journal of Engineering Education*, *29*(4), 879–890.
Treffinger, D., Young, G., Shelby, E., & Shepardson, C. (2002). *Assessing creativity: A guide for educators*. Storrs, CT: The National Research Center on the Gifted and Talented.
Tsui, L. (1999). Courses and instruction affecting critical thinking. *Research in Higher Education*, *40*(2), 185–200.
Wince-Smith, D. L. (2006). *The creativity imperative: A national perspective. Peer review. Spring.*. Retrieved from https://www.aacu.org/peerreview/pr-sp06/documents/PRSP06_analysis3.pdf (March 10, 2014)