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The role of failure in learning how to create in art and design

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ABSTRACT

There is evidence that failure can contribute to creativity, but there has been no research on whether failure plays a role in teaching and learning how to create. In this paper, I examine the role of failure in teaching and learning in professional schools of art and design, where creative practice is an important learning outcome. In the course of ethnographies at two professional schools of art and design, I interviewed professors and observed their classes to explore their pedagogical beliefs and practices. Using a grounded theory methodology to analyze this qualitative data, I found that failure is an important aspect of pedagogy in both art and design disciplines. The grounded theory methodology resulted in the identification of six emergent themes that elaborate how art and design pedagogy incorporates failure to foster creative learning outcomes.

1. Introduction

Many anecdotes, case studies, and biographies provide examples of moments of failure contributing to eventual creative success. Leaders of innovative technology companies and design firms often say that one must fail to innovate (e.g., Wylie, 2001). Many business writings on innovation claim that a successful creative company "rewards people for success but gives them permission to fail" (Brown, 2009, p. 32). Case studies of failures that eventually contributed to successful innovation abound in the business literature (e.g., Kelley, 2001). Biographies of famous creators often describe their failures; for example, Albert Einstein encountered so many failures that a book has been published called *Einstein's Mistakes* (Ohanian, 2009).

The observation that failure can contribute to creative outcomes motivates my research question: Could failure play a role in teaching and learning to be creative? To address this research question, I studied teaching and learning in professional schools of art and design. Previous research has demonstrated that this pedagogy is designed to lead to creative learning outcomes (Sawyer, 2017). A related research question is: If we find that failure plays a role in art and design pedagogy, what pedagogical techniques are used to incorporate failure as a productive force in learning?

2. Literature review

I did not find any previous studies of the role of failure in teaching and learning in art and design classrooms. A 2017 literature review (Sawyer, 2017) identified 65 journal articles that studied art and design pedagogy in both K-12 and in university; none of these articles addressed the role of failure. Although there have been no studies that directly explore the research question, I identified three bodies of literature that are related to the research question—the role of failure in learning, the role of failure in the creative process, and studies of art and design pedagogy.

2.1. The role of failure in learning

Many studies have documented that failure, when carefully incorporated into project assignment designs in math and science,

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results in deeper and more effective learning (e.g., Kapur, 2008, 2010; Kapur & Bielaczyc, 2012). Not all failures are beneficial to learning; student failure could indicate a lack of understanding or learning, or could be a sign of poor assignment design or ineffective teaching. However, a carefully designed type of failure, referred to as *productive failure*, results in more effective learning and deeper conceptual understanding.

In productive failure pedagogical designs, learners are presented with challenging, ambiguous, and ill-structured problems (Kapur, 2008). The problems are beyond the student's current ability, and are too difficult for the students to solve, but students are nonetheless asked to work towards a solution. As students work to solve the problem, they develop multiple representations and solutions; typically, these are not successful. Consequently, students reach an impasse and are not able to move forward to a correct answer. At this point, the teacher provides students with an explanation of the solution to the problem, and helps the students to understand why they developed the incorrect solution. This examination of the correct solution, combined with an analysis of their own incorrect solutions, provides the student with an opportunity to discern the deep structure of the problem (e.g., Kapur, 2008, 2010). In this pedagogical design, students more successfully learn a deeper conceptual understanding of the material, when compared to learners who completed well-structured problems without encountering failure (also see Kapur & Bielaczyc, 2012).

In a study of *impasse-driven learning*, VanLehn, Siler, Murray, Yamauchi, and Baggett, (2003) found that successful learning was more likely when students experienced an impasse—a temporary mental block while attempting to solve a problem—and were only then provided with a correct understanding and solution. VanLehn et al. (2003) concluded that when students did not experience an impasse, "learning was rare" (p. 380).

Productive failure has been found to contribute to learning in science (e.g., Kapur, 2008) and in math (e.g., Kapur & Bielaczyc, 2012). However, productive failure has not been studied in art or design subjects, and it remains unknown whether productive failure would be an effective pedagogical technique in art and design education, or in creative education more generally.

2.2. The role of failure in the creative process

Creativity research has found that failure is often associated with creative insight. Insights are sometimes preceded by an *impasse*— a fixation on an incorrect solution (see the reviews in Lubart, 2001; Sawyer, 2012). For example, in the famous 9-dot problem (see Fig. 1), subjects often fixate on drawing lines within the box formed by the dots. Although the subject quickly realizes that the inside-the-box solution is incorrect, the fixation nonetheless prevents the subject from identifying the correct solution. A moment of insight occurs when a person suddenly overcomes the fixation, and identifies the correct solution (e.g., Öllinger, Jones, Faber, & Knoblich, 2013; Kershaw & Ohlsson, 2004). Similar findings of an impasse-insight-solution sequence have been reported with other creative insight problems (Metcalfe & Wiebe, 1987; Schooler, Fallshore, & Fiore, 1995).

Other studies have extended this research on insight problems, and have found that successful creative works often emerge from an extended process, with multiple moments of impasse and insight. These studies have found that the creative process proceeds in a cyclical or recursive fashion, with failures often the cause of these unexpected new directions (Finke, Ward, & Smith, 1992; Gruber, 1988; Mumford, Mobley, Uhlman, Rieter-Palmon, & Doares, 1991; see additional citations in Lubart, 2001, p. 304).

Studies of the work processes of artists and designers have likewise found that they engage in an iterative process (Halverson, 2013), and that creativity resides in the small ideas that occur frequently through this process (e.g., Cross, 2011, p. 145; Mace & Ward, 2002; Sawyer, 2012, pp. 138–139; Sawyer, 2018). For example, studies of *design thinking* have documented an iterative design process, with shifts in direction, frequent dead ends, and outcomes that were not anticipated at the beginning of the process. The design process is "iterative, nonlinear," "an exploratory process," involving dead ends or failures, and with "unexpected discoveries along the way" (Brown, 2009, p. 16). Rather than a sudden moment of insight that drives creativity, small ideas occur frequently as single moments in a longer process, and although these small ideas sometimes fail, those failures nonetheless drive the process forward toward eventual success.

2.3. Teaching and learning in art and design

A recent literature review of empirical studies of art and design pedagogy (Sawyer, 2017) identified 65 journal articles. The review found that art and design pedagogy is constructivist and learner focused. Classroom work centers on open-ended project assignments. Students participate actively in generating creative work under the guidance of the instructor. However, this literature review did not identify any studies of the role of failure in art and design pedagogy. Due to this absence of empirical studies, we do

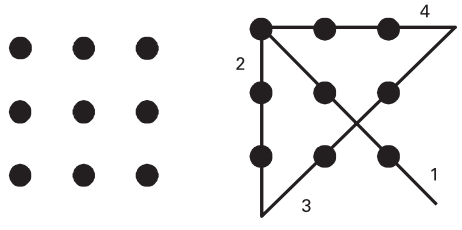

Fig. 1. The nine-dot problem. Connect the grid of nine dots at the left by drawing four connected lines without lifting your pencil. The solution is at the right.

Table 1
Professors interviewed and class observations.

	Professors	Class observations	Interviews
SCAD	22	8 (10 h, 29 m)	35 (19:50)
WU	16	9 (10:43)	19 (16:24)
Total	38	17 (21:12)	54 (36:14)

Note: This table reports the total number of observations and interviews conducted, followed by the total duration of all audio and video recordings as (hh:mm). Thirty three professors were interviewed, 15 two or three times, for a total of 54 interviews. Fifteen professors were observed, two more than once, for a total of 17 observations. Twelve professors were both interviewed and observed. Total data recorded, transcribed, and coded = 57 h, 26 min.

not yet know to what extent art and design instructors incorporate failure in their classrooms.

2.4. Summary of prior research

The productive failure literature demonstrates that when failure is designed into the learning process, learning outcomes are enhanced. The creativity research literature documents that failure can contribute to creative outcomes. And yet, studies of art and design pedagogy have not examined pedagogical uses of failure. This literature review motivates my research question: Could failure play a role in teaching and learning to be creative in art and design?

3. Methodology

This study draws on a subset of data gathered as part of a larger study of teaching and learning in art and design (Sawyer, 2018). Ethnographic studies were conducted at two quite different institutions of higher education, both in the United States: Washington University (WU), a comprehensive research university which, in addition to a full suite of degree programs in science, humanities, social sciences, and the professions, also has an art and design school; and Savannah College of Art & Design (SCAD), a specialized art and design college offering primarily art and design degrees.

In the course of these two ethnographies, I interviewed 33 professors, many two or three times, for a total of 54 interviews, and I observed 17 studio classes of 15 professors (two professors were observed twice). Twelve of the professors were both interviewed and observed (see Table 1). The professors were recommended by their Deans, their department chairs, or their colleagues for their recognized abilities as excellent and experienced teachers. The average years of teaching experience was just over 14 years. I also asked for recommendations in a broad range of disciplines, in both art and in design. A total of 15 art and design disciplines are represented in the dataset, including disciplines as varied as painting, sculpture, interior design, and advertising. The total dataset contained 54 professor interviews, for a total audio duration of 36 h and 14 min; and 17 studio classroom observations, for a total recorded duration of 21 h and 12 min. All video and audio recordings were transcribed. Following an ethnographic methodology, observations and interviews were not structured in advance, to allow pedagogical practices and beliefs to be captured in the data. Studio classes were observed quietly, from the rear of the class. Interviews were open-ended discussions of the professor's practices and beliefs. I began each interview by asking "How do you teach students to be creative?" The interview then was conducted in a free-flowing manner, with subsequent questions motivated by the participant's previous answers. No structured protocol was used; the intent was that the flow of the interview would be driven by the professors' own choices of what they thought was important in their studio pedagogy.

I analyzed the transcribed data using a *grounded theory methodology* to allow the beliefs and practices of these professors to emerge from the ethnographic data. I chose to use this inductive methodology, rather than a deductive theory-driven approach with a pre-determined set of coding categories, for two related reasons. First, when a deductive approach is used to analyze ethnographic data, it risks imposing an invalid theoretical framework on the data, resulting in a failure to identify important empirical phenomena that were not incorporated in that theory (Levitt et al., 2018). Second, there are not yet theoretical frameworks available to explain teaching and learning in art and design. Grounded theory methodology is designed so that theory is inductively developed in a way that is grounded in the data. Detailed descriptions of the grounded theory methodology used here can be found in Charmaz (2014), pp. 114–115); Glaser (1978), 1992); Glaser and Strauss (1967); and Strauss and Corbin (1990). The grounded theory analysis involved multiple successive stages, as recommended and described in these methodology texts; a concise summary of this process follows.

I began by analyzing the complete dataset of transcripts, including both the 54 interviews and the 17 studio observations, to identify dialogue turns that related to teaching and learning the creative process. Each of these dialogue turns was given a short description, which was typically fine-grained and quite specific to that turn, to reduce the potential for imposing my own existing concepts and theories onto these observations. I then used successive stages of *constant comparison*: in each iterative stage, the dataset was re-analyzed using the current set of emergent themes, resulting in the *integration*, or merging, of related pairs of themes to develop a more general and more broadly applicable theme (Glaser & Strauss, 1967). Because my research goal was to identify pedagogical themes that are characteristic of both art and design pedagogy, and also that are found in multiple institutions, an emergent theme was only identified if it was found at least once at each institution and at least once in both an art discipline and a design discipline—a total of at least four instances for each theme. (However, note that in grounded theory methodology, themes are

not required to meet a threshold of proportion or distribution; see Charmaz, 2014, p. 145.) The iterative process of analysis ended when it reached *saturation*—when it was no longer possible to merge any of the two remaining themes (Charmaz, 2014; Corbin & Strauss, 2008).

4. Findings

The methodology resulted in the identification of 45 emergent themes, each found in both an art discipline and a design discipline and at both institutions (see Sawyer, 2018, Appendix A, for a complete list of the 45 themes). Because the themes were found in a variety of disciplines and institutions, they represent beliefs and practices that are likely to be general in art and design education. To address the research question, "Could failure play a role in teaching and learning to be creative?", I examined the 45 themes to see if any were related to failure and learning. The answer to the research question is affirmative: I identified six themes related to the role of failure in teaching and learning in art and design. The other 39 themes were related to other aspects of pedagogy, and fell into three categories that are also represented in these six themes: intended learning outcomes, assignment designs, and classroom practices. The six themes are:

1 Learning outcome: An important learning outcome is the ability to use failure productively in the creative process.
2 Open-ended assignments: Assignments are problem-based and open-ended so that students have to discover their own formulation of the problem and develop their own path to completion.
3 Intended failure: Assignment designs lead students to fail. Professors believe that this helps students learn how failure can drive the creative process forward.
4 Student frustration: Often students get frustrated by the ambiguity inherent in open-ended assignments. The ambiguity is necessary because it allows each student the opportunity to develop their own creative approach to the assignment.
5 Student requests: When assignments are ambiguous, students often ask for more specifics. Instructors believe that it is important to not provide more specifics, because this would prevent them from encountering failure as they work through the creative process.
6 Constructive feedback: When students encounter failure, professors do not tell them how to overcome that failure, or what they should do next; instead, they guide students in working through the failure independently.

In the presentation of these six themes, in the corresponding sections below, I use representative quotations from the interviews. Each of the themes was also observed in videos of studio interactions, indicating that the professor's pedagogical practices are consistent with the statements they made during interviews.

4.1. The learning outcome: mastery of the creative process

According to these professors, who are themselves professional artists and designers, failure is an essential part of a successful creative process. A painting professor told me "The first iteration never is the one that works." The creative process begins with ambiguity in an ill-structured context. The creator begins by conducting an exploration, starting to work without knowing what creative idea will emerge, or how the final product will unfold. In this experimental and iterative process, there are often dead ends—ideas that are not very good, or paths that turn out not to lead to a successful work. These frequent failures are conceived of as small moments that are necessary and expected. Professional creative expertise involves mastering the ability to build on failures, and to weave the failures into a longer process that ultimately leads to success.

Among these professors, a failure is considered to be a small moment in the context of an iterative, wandering, and unpredictable creative process. They believe that the creative process is more likely to end in success when failures occur early in the process—when early experiments do not work out, when materials of the medium do not realize an idea as initially expected, or when conceptual dead ends are encountered. Professional creatives then are able to build on, and learn from, these early failures, to drive the creative process forward and ultimately lead to successful work.

Student mastery of this creative process is an important learning outcome of art and design education. Professors believe that student failure is an important part of art and design pedagogy, so that students will gain hands-on experience in encountering and overcoming failure. Professors not only believe that failure contributes to learning; they make the stronger statement, that failure is essential to learning. A professor of graphic design told me that "For true learning to take place, in my opinion, there has to be some level of failure. Or lack of success." A professor of illustration said "They don't learn the point unless they fail first—they realize the mistake they made, and why. That's really important."

4.2. Professors design ambiguous and open-ended assignments

In most art and design classes, students are presented with projects that typically take two or more weeks to complete. These projects are open-ended and ill-structured to allow students to experience the nonlinear and iterative creative process. A professor of advertising said "They have to learn through experimentation and discovery." Although open-ended, project assignments are nonetheless guided by carefully designed parameters and constraints. Professors say that without some constraints, students are not challenged; they do what they already know how to do, and they use concepts and tools they have already mastered. Professors invest substantial thought and energy in the design of their project assignments, and in the selection of these constraints. Project constraints

scaffold students as they work through a version of the creative process appropriate to their level of development.

Professors often refer to these assignments as "problems" and they say that "problem solving" is an important learning outcome. For example, an architecture professor said she is teaching students "how to come up with creative solutions to problems" and that her goal is "to practice problem solving skills." An illustration professor told me that his goal was for students to learn how to create "unique and distinctive solutions to the problems within the criteria given." And yet, unlike math and science education, their use of the word "solution" does not refer to a single correct answer. Professors say that each student must develop their own way to think about the problem, and develop their own unique solution.

Professors believe that students have to learn to work with ambiguity or they will not be professionally successful. A professor of graphic design told me: "to be effective in a creative landscape is to know how to operate in a world of ambiguity." When faced with the ambiguity of open-ended assignments, students must follow their own path through the process. There is not a single obvious way forward: "you never know exactly what you're going to need to do to get to the end" (a professor of first-year foundations).

These assignment designs are similar to those used in *project-based learning* (Krajcik & Blumenfeld, 2014) and in *problem based learning* (Lu, Bridges, & Hmelo-Silver, 2014), in that those pedagogical approaches—primarily implemented and studied in STEM classes—are based on open, ill-defined problems. In the course of the two ethnographies, I reviewed a broad range of the printed project assignments used by professors, and they almost all have the features that Jonassen (2000) associated with ill-structured problems: They specify a range of parameters while leaving many unstated, to be creatively determined by the learner; the parameters interact with each other in interesting ways; and they allow for multiple paths forward.

These art and design class assignments have many similarities to the ill-structured designs used in studies of productive failure, where the problems have several characteristics associated with open-ended project assignments, including "multiple solutions and paths" (e.g., Kapur, 2008, p. 387). As with productive failure designs, these assignments have constraints that prevent students from using strategies that they have already mastered. Students have to experiment with new strategies that go beyond their current level of ability: "problems that are beyond their skill sets and abilities" (Kapur, 2008, p. 414). Many assignments require students to propose a specific number of ideas, options, or possibilities, before choosing one to pursue. Professors believe that when students generate a broad range of potential paths forward, they better learn the creative process.

When assignment parameters are overly specific and constraining, students are able to quickly follow a fairly linear path to completion. In this case, professors believe that there is not sufficient ambiguity, and they reduce the project constraints. Studies of non-arts subjects have also found that when learners are faced with problems that are well-structured "the learner is either able to solve the problem quickly or simply gives up" (Kapur & Bielaczyc, 2012, p. 6).

As with these art and design professors, the problems used in productive failure designs must be "calibrated" to find "a sweet spot where students are challenged yet not frustrated and remain sufficiently engaged" (Kapur & Bielaczyc, 2012, p. 50). Art and design professors constantly calibrate their assignment designs; they say that they can tell when the project parameters are too constraining, and also when they are not constraining enough.

4.3. Assignments are designed so that students fail early

To help students learn and to take risks and to use failure as a productive moment in an ongoing creative process, many professors design assignments that frequently lead students to fail. They explain that these failures are necessary for students to learn how to master the creative process. An architecture professor told me "Unless you force them into that kind of discomfort and get them to take lots of risks" they do not learn. In a study by McKenna (2011), a sculpture professor said "I had the students set out to create failures. They had two weeks for homework to create an utter failure" (p. 163) These assignments help students learn to use failure productively to drive the creative process.

Professors distinguish between productive failures—those that help students learn to master the creative process—and failures that are not helpful for students. A professor of graphic design said:

> It's OK, encouraging them to fail. It doesn't mean with the end outcome. Sometimes the end outcomes fail miserably. Quite often, you know, more often they're successful, because that failure has taken place earlier in the investigation…. And the first couple of weeks of those things can often be just absolutely awful, where there're multiple failures for students."

In productive failure project designs in math and science subjects, students are presented with an ill-structured problem that is designed so that students encounter an impasse. They are then presented with the correct solution, followed by a pedagogical interaction that helps them understand the nature of their failure. Art and design assignments, although there is not one right answer, nonetheless share many features with these math and science projects. In both, student failure is thought to be most productive when it occurs early in the process. As with productive failure in science subjects, art and design students learn best when these early failures are followed by a deeper understanding of the problem, one that allows the learner to reflect on why they failed on their initial attempt.

4.4. Student frustration drives learning

Students do not yet know how to work within ambiguity. As a result, when working on these open-ended assignments, they often feel frustrated. Professors know that this is likely to happen, and they realize that it can be difficult for the student, but they believe that this frustration benefits learning. A professor of first-year foundations said that students get "frustrated about the lack of structure" but by the end of the course, "they were really glad they'd gone through it." A professor of graphic design told me "They

should be uncomfortable in the beginning. I tell my students, I want you to be uncomfortable." A professor of illustration told me that a good learning experience is "typically one that involves frustration" so that the knowledge is "owned".

The two universities studied here attract good students, with a history of academic success. The students who enter these programs have chosen to pursue a creative career, and they are motivated to learn and to do well in their courses. When presented with a project, students want to know how to satisfy the instructor and get a good grade. Based on their previous school experience, they believe that the most effective instruction is that which is very explicit about what they are supposed to do, and very clear about what constitutes success. The open-ended nature of ill-structured problems challenges these assumptions. A typeface designer told me "They've all been trained to get the right answer." An illustration professor described students as "trying to figure out what the right answer is…The loathing of ambiguity…to be effective in a creative landscape is to know how to operate in a world of ambiguity."

A professor of painting said that when students are frustrated, they sometimes blame the instructor for ineffective pedagogy. In a study of design education, Lawson and Dorst (2009) wrote that "The unsuspecting student might feel disoriented and wonder why the design school has suddenly become very vague in its criteria ("What do you want me to do?")" (p. 244). They observed a class session in which an angry engineering student came to his instructor and said "I have a right to know what the problem is!" (p. 245). Because these student reactions are common, art and design professors say that it is important to explain to students why frustration and failure are necessary. A graphic design professor said: "in all of my classes I am, you know. Very careful to / to talk about what failure means. That failure means trying something new and not getting the right result the first time, but being committed to constantly challenging and trying new ideas."

In the inquiry-based STEM curricular designs known as *case-based reasoning* (Kolodner et al., 2003), students likewise have difficulty understanding why they must experience failure: "It is difficult for students to differentiate…failure that you can learn from and failure" (p. 512). Productive failure studies have likewise documented that students are often frustrated by these project designs, because "the usual norm is getting to the correct answer in the most efficient manner" (Kapur & Bielaczyc, 2012, p. 52).

In many studies of productive failure in math and science, projects are designed to avoid student frustration, posing problems "that challenge but do not frustrate" (Kapur & Bielaczyc, 2012, p. 49; also see page 50 on calibration). For example, this has been found helpful when students are presented with ill-structured problems in grade 7 math class (Kapur & Bielaczyc, 2012). Teachers were instructed to tell the students to try various ways of solving the problem, and to emphasize that there were multiple representation and solution methods (p. 52). However, the teachers did not explain that it was acceptable to fail, and did not explain why or how this failure contributed to learning.

4.5. Responding to requests for more specifics

When students become frustrated while working on these ill-structured problems, they often ask their teacher to provide additional specificity that would reduce the ambiguity they face. Sometimes students ask for additional information even before they begin to work on a problem (Lawson & Dorst, 2009, p. 244). Professors said that it is important to not provide more specific details about the design challenge, because that prevents students from discovering their own way to approach the project. A student's request for specifics is often driven by a concern for grades. A professor of illustration told me that when a student asks "how to get an A, I can't tell you that." So he knows "You're going to bug the hell out of people." When describing situations when students ask for more specifics, an architecture professor told me that "it's an incredibly silly question if you're a serious learner"; and that it is a sign that the students "don't want to do the hard work of figuring it out themselves."

The decision not to provide specifics, so that students have to choose a way forward in the presence of ambiguity, is consistent with studies of productive failure in science and math classes. In these studies, students are presented with open-ended problems and are asked to generate multiple potential solutions. Students are used to asking for help from the teacher, and they sometimes ask for help before they even attempt the problem on their own. Research on *impasse-driven learning* (VanLehn et al., 2003) has found that it is more productive for learning if teachers wait until the learner has reached an impasse, and then provide the learner with guidance to a successful learning outcome.

Art and design professors allow students to fail because they believe that it is important in fostering creative success. In contrast, most middle-school math and science teachers tend to think that student failure is detrimental to learning. Instead, they are used to providing assistance, and they find it difficult not to help students when they are frustrated by a problem. As a result, studies of productive failure have found that it is important to advise teachers "to not provide assistance when asked but rather to constantly assure students that it was okay not to be able to solve the complex problems as long as they tried various ways of solving them" (Kapur & Bielaczyc, 2012, p. 52).

4.6. Professors guide students to learn from failure

As students work on these projects, they fail in small ways that are appropriate for their level of understanding. Professors are expecting students to fail, and when they do, they are prepared to guide students to learn from the failure. An illustration professor said "[A good instructor] takes a more frontal assault to the issue of ambiguity and sort of throws them into the deep end of the pool. And then guides them." In response to a failure, instructors engage the student in a discussion about why it happened. Their goal is to increase the student's ability to reflect on the role of failure in his/her creative process.

In the face of ambiguity and frustration, a risk is that learners may give up too easily. Kapur (2008) hypothesized that if learners give up too easily, productive failure designs do not work. In the face of open-ended assignments in math and science, learners need "persistence and tenacity," the desire to continue to engage in the work even while they are struggling and failing (p. 414). Art and

design college students are highly motivated, and they typically demonstrate a high level of persistence as they work through their failure and frustration. Nonetheless, failure can be demoralizing, and these professors spend substantial time one-on-one—guiding students to be comfortable with the experience of failure, explaining why it is necessary, and how it will help them master the creative process. As Kapur and Bielaczyc (2012) found, to convert failure to productive failure, teachers need to "constantly assure students that it was okay" not to be able to solve the problem (p. 52).

Most failures occur early in the creative process, when there is ample time to recover before the assignment is due, but there are times when a student fails immediately before the due date. The student is working hard to meet the schedule, and is almost finished with a project, when she reaches an unsurmountable dead end, and realizes that she has to start over from the beginning. A sculpture professor told me that he has often seen students fail in this more dramatic fashion, and he provides quite a bit of support and positive feedback when this happens. Professors know that these situations sometimes happen, and they guide students how to learn from them (cf. Collins & Kapur, 2014), and also to help students understand that such failures are a normal and expected part of the creative process.

Studies of productive failure have demonstrated that learning is more effective when the instructor does not provide support during the initial phase. This finding is consistent with Theme 5; professors do not provide additional assignment details. And yet, there seems to be a difference, in that these professors provide guidance, and help students learn to work through failure. In contrast, in many studies of productive failure, the instructor is relatively absent from the learning situation. In Kapur's (2008) experimental designs, students work "without the provision of any external support structures or scaffolds….left to their own devices….No help or support was provided to any group during problem solving" (p. 385). Because past studies of productive failure have not detailed the type of support provided by these instructors, it is unclear how effective it would be in math and science to support students in this way.

5. Discussion

My research question was: Could failure play a role in teaching and learning to be creative? A related research question was: If we find that failure plays a role in art and design pedagogy, what pedagogical techniques are used to incorporate failure as a productive force in learning? I addressed these research questions by studying art and design pedagogy in higher education. These findings provide answers to both research questions: I found that failure plays an important role in teaching and learning in university programs in art and design, and I identified six themes related to the role of failure in these programs. The findings are consistent with prior studies of productive failure in math and science. In both, the pedagogy is project-based. In both, students work on ill-structured and open-ended assignments. In both, projects are designed to present the learner with an ambiguous challenge. In both, while exploring the potential problem space, the learner can pursue a range of plausible possible paths. And in both, while engaging in this exploration, the learner acquires a better understanding of the nature of problem spaces and of working through problems more generally.

This study provides evidence that our understandings of productive failure, derived from math and science classrooms, may generalize to art and design education. In addition, this study has identified a variety of interesting differences. The six features of failure in art and design pedagogy, reported here, could help to elaborate our understanding of productive failure in math and science. The inverse is also true: our current understandings of productive failure, developed from studies of math and science, could inform art and design pedagogy. In the following, I identify several contrasts, and explore potential opportunities for future research.

5.1. Student understandings of failure

In productive failure designs in math and science, the student does not necessarily know that their answer is wrong until the instructor points it out. In art and design, the students usually recognize when they have encountered a dead end, without the instructor pointing it out. However, they do not necessarily know why they have reached this moment of failure, and they do not know how to use it productively in their continuing creative process. Art and design professors encourage students to examine their failures, to develop explanations for why they failed, and to explore how they might build on the failure and move forward. Reflection on failure can contribute to learning, as Kolodner et al. (2003) write in a study of case-based reasoning (CBR) in problem-based science classrooms: "CBR thus gives failure a central role in promoting learning because failure promotes a need to explain….When such failures happen in the context of attempting to achieve a personally meaningful goal, the reasoner wants to explain so that he or she can be more successful" (pp. 502–503). These professors' practices are consistent with research on metacognition, which has found that learning is more effective when learners reflect on their own learning process (Winne & Azevedo, 2014). It might be productive to further explore how professors foster a student's ability to reflect on their creative process.

5.2. Intended learning outcomes

Studies of productive failure have focused on math and science, and the intended learning outcome is disciplinary content knowledge. After students develop an incorrect answer, the instructor provides the correct solution, and guides the student to understand how their own solution relates to it. In contrast, in art and design education, the intended learning outcomes differ in two ways.

First, a problem presented in an art or design assignment does not have a single correct solution. Each student follows their own creative path through the process, and each student's creation is different from the others. When students reach an impasse,

professors do not tell students what do to next. Instead, they guide students to make their own decisions, and they help students understand how to make such decisions: "I wanted to reinforce that you're making decisions all along the way" (a painting professor).

Second, in art and design pedagogy, I found that failure is used to help students learn domain-general aspects of the creative process. The grounded theory methodology used here required that each theme be found in both art and design disciplines, and as a result, the six themes that emerged are not specific to any one creative discipline. Art and design students must master their own discipline's techniques, as well. For example, painting students need to master the techniques of painting—such as how to mix paints to achieve a certain color effect, or how to hold a brush to get a particular texture on the canvas. The findings reported here do not address these discipline-specific learning outcomes; the six themes are not limited to any one creative discipline. In both art and design disciplines, failure is incorporated into pedagogy so that students learn a general creative ability to use failure productively. This seems different from productive failure designs in math and science—where the intended learning outcome includes not only problem-solving ability, but also specific disciplinary knowledge: the correct answer, and an understanding of why it is correct.

Future research might consider how to adapt these pedagogical practices for non-arts disciplines, when creative practice is an important learning outcome. For example, in physics, might students learn to engage in creative problem solving—using physics knowledge, concepts, and methods—through curricular designs similar to the ones documented here?

5.3. Conceptions of failure

In productive failure project designs in math and science, failure usually occurs a single time while solving a problem, followed by teacher presentation of the correct solution. In contrast, in art and design, there can be multiple moments of failure as a student works on a project. Each student may encounter a different number of failures. When students fail, this does not mean that they have developed an incorrect answer, one that results in an impasse and that then requires the instructor to provide the correct solution. Rather, failure is a temporary dead end in an extended creative process, and multiple moments of failure often occur in this extended creative process, with each of them contributing to learning.

5.4. The balance between ambiguity and structure

In both art and design and in math and science projects, instructors use open-ended assignments, and students have to find their own way forward. Prior studies of productive failure in math and science have noted the need to *calibrate* the balance between ambiguity and structure, so that students are not able to get the right answer, and yet, do not become frustrated by this (e.g., Kapur & Bielaczyc, 2012, pp. 49–50). In art and design pedagogy, calibration is managed differently. Students are thought to learn more effectively when they become frustrated. As a result, effective productive failure project designs in math and science might be more constraining, whereas art and design projects might be more open-ended.

This raises several questions for future research. Is it the case that art and design projects are less constrained? Future research could examine the project assignments that lead to productive failure in math and science, and compare their structure to these art and design projects. If there are such differences, why is the balance between ambiguity and constraint different in these subjects? What is the optimal balance for each discipline's intended learning outcome? In math and science learning, creative problem solving ability is now recognized to be an important learning outcome (e.g., Craft, 2005; Sawyer, 2006). To support creative learning outcomes in math and science, project designs may need to incorporate greater ambiguity.

5.5. Teacher beliefs about student failure

In the interviews, professors were able to articulate why failure was important for learning. They have developed a set of classroom techniques that are intended to maximize the pedagogical benefits of student failures. They were equally articulate about how productive failure would be fostered by their own specific project designs, and also by their style of interaction with students. When observing studio class sessions, I observed many instances where professors explained to their students why ambiguity, frustration, and failure are important to learning.

Whereas these professors welcome and encourage student failure, math and science teachers generally believe that students should be provided with assistance when they fail. When productive failure projects are introduced to math and science teachers, they must be instructed not to provide assistance (for example, as reported by Kapur & Bielaczyc, 2012).

Prior studies of productive failure do not provide much information on the beliefs of these math and science teachers. In these experiments, are the participating teachers provided with information on the benefits of failure for learning? What do teachers think about the productive failure project designs introduced by the researchers? Do they perceive some benefits, or are they skeptical of the researcher's intervention, or do they reject the technique completely? How might we design professional development to share this research with teachers? These findings might provide useful suggestions for how to educate math and science teachers in the benefits of productive failure.

5.6. The role of the instructor

In studio classes, students work on their projects in the presence of the professor. The professor circulates the classroom and is readily available. I often saw professors discussing student failures with the student, while the student was struggling with that failure. I saw professors guiding students to learn from that impasse, and to then find their own way forward.

In math and science subjects, failure has been found to be more productive for learning when no "support structures or scaffolds" are provided (Kapur, 2008, p. 385). In some studies of productive failure, teachers are not present at all. And when teachers are present, they are instructed not to help students with the problems. They are instead told "to constantly assure students that is was okay not to be able to solve the complex problems so long as they tried various ways of solving them" (Kapur & Bielaczyc, 2012, p. 52),

In productive failure experimental designs, "monitoring" and "feedback" are only provided in the direct instruction condition (e.g., Kapur & Bielaczyc, 2012, p. 64). The direct instruction condition results in less effective learning than the productive failure condition. In the art and design classes I observed, it seemed that the instructors "monitor" student work, and provide "feedback" when students encounter an impasse. This raises a potential research question: are there different levels of instructor support that are optimal for learning in different subjects? Why might instructor feedback be beneficial in art and design, but not in math and science? When a student fails, when is the optimal moment to provide support—should the instructor monitor for student failure, and initiate an intervention, or instead wait for the student to ask for help?

Future research might explore different types of instructor monitoring and feedback, and explore how different types of feedback might vary with the discipline (art and design vs. math and science) or with the intended learning outcome (subject-area knowledge vs. creative process mastery). Although art and design professors provide support for students when they fail, they do not provide the sort of direct guidance that a math or science professor would: They intentionally avoid saying whether the student's proposed next steps are more or less likely to lead to a successful creative work. Rather, their feedback involves emotional support, and helps students learn how to approach failure more generally, and how to work through that failure.

6. Conclusion

To examine the role of failure in teaching and learning in creative domains, I conducted an empirical study of pedagogical beliefs and practices in two colleges of art and design. I found that failure plays an important role in art and design pedagogy. The findings are largely consistent with what we know about productive failure in math and science. In addition to these similarities, I found several apparent contrasts. To further explore similarities and differences with productive failure in math and science, I have suggested potential questions for future research.

This study also contributes to our understanding of how to teach students in ways that lead to creative learning outcomes. Creativity researchers have not explored how failure during learning might contribute to enhanced creative performance. I found that art and design professors incorporate failure into their pedagogy with the goal of helping students master the creative process. The findings are consistent with creativity research, which has demonstrated that impasses contribute to insight; and are complementary with studies of the creative process of artists and designers, which document the role of failure in that process. Because art and design are fundamentally creative disciplines, these pedagogical practices might be used to design creativity training for students more generally. Future studies could explore whether these findings extend to pedagogy in other creative domains, such as writing or music.

This study has several limitations. First, I am not able to make causal claims that these pedagogical techniques help students learn to more successfully engage in the creative process. Although I have documented that professors incorporate failure into their pedagogy, and that professors believe these techniques help students learn to engage in the creative process, I cannot claim that it does so. Second, I have not explored in detail the design of project assignments used by art and design professors. Although these professors refer to their assignments as "problems," and they intend for students to learn problem solving skills, their concept of problem solving is likely to be different from that used in math and science. These problems have multiple possible solutions, whereas math and science problems typically have a single correct solution. A more detailed examination of problem designs might allow a fuller exploration of similarities and differences with problem-based learning in math and science. For example, problem-based pedagogies in science are designed so that learners have multiple potential paths toward a solution—which is similar to art and design problems—and yet, the nature of the solutions is different. A third limitation of this study is that I have not observed and documented the activities of the learners as they work through these problems. Productive failure research in math and science has often examined the learner's problem-solving processes, and future studies of art and design pedagogy could likewise explore the learning processes of students as they work on these ill-structured problems.

In sum, art and design pedagogy is designed so that students encounter failures and learn from those failures. These findings contribute to productive failure research by extending existing models, developed from STEM learning, to previously-unstudied creative disciplines. Art and design pedagogy intentionally uses failure in ways that are designed to be productive for learning the creative process. These findings contribute to creativity research by demonstrating that failure is used in teaching in creative disciplines; by identifying six specific features of the pedagogy that are designed to lead students to fail; and by suggesting how this use of failure in teaching can help students master the creative process.

I hope that this paper contributes to the goal of this special issue, by helping "to re-establish failure as an essential and beneficial component of learning—especially in the development of critical thinking, inventiveness, and creativity" (Call for papers, 2017).

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