Student Experiences In An Interdisciplinary Studio-Based Design Course: The Role Of Peer Scaffolding

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Introduction

The process of learning is based on a student's experiences that lead to change in their knowledge (Ambrose, Bridges, DiPietro, Lovett, & Norman, 2010). The environment where students learn, the model of teaching that is practiced and how someone provides assistance to another, all play a crucial role in the learning process. Wanting to investigate students' perspectives on their experiences in a studio-based design course, we took a grounded approach to this pilot study in order to allow salient themes to emerge. Peer scaffolding was one of the major themes that appeared during this preliminary study, regarding the student learning process. Scaffolding, i.e. when a parent, teacher or more knowledgeable peer provides assistance to a learner, played a crucial role in student learning in the observed studio course (Wood, Bruner, & Ross, 1976). In this particular environment both faculty and peers offered scaffolding, however for this paper we particularly focus on peer scaffolding.

Alternative models of teaching, beyond traditional classroom-based lectures, are important approaches in design education. Studio-based methods have been effectively used in design education, specifically in architecture and industrial design. "Learning by doing" is typically the main focus of the studio model. The notion of "doing" or "hands-on" of the studio model has generated enthusiasm in higher education for other disciplines to adopt such model of teaching and learning. Courses in computer science, civil engineering, first year engineering and interdisciplinary courses have been designed based on the studio model (Brandt et al., 2013; Kuhn, 2001; Little & Cardenas, 2001; Wilson & Jennings, 2000). In engineering, design is considered widely to be the central activity (Dym, Agogino, Eris, Frey, & Leifer, 2005; Simon, 1996). However, engineering student design experiences are limited and mainly come from first year general engineering, capstone design, internships/coops or interdisciplinary classes (Dym et al., 2005).

In this study we use scaffolding as a lens to investigate engineering students' perception of design in a studio model. In the process we also investigate which scaffolding attributes are being exhibited by students in the interdisciplinary studio courses.

Literature Review

Different models of teaching and learning in higher education provide engineering students diverse learning experiences at academic institutions. Engineering courses are still mostly lecture and laboratory based (Grayson, 1993). Engineers learn and exercise their theories and practices within particular social settings - within classrooms, within a laboratory, and during the design review (Bucciarelli, 2001 , p. 298). In this study we consider the studio environment as a social classroom setting (where some laboratory facilities are within the students reach) and where students are engage in the process of design. I

Studio Model

A slightly different teaching and learning model in technical education is the "studio model" (Little & Cardenas, 2001). According to Kuhn (2001), Little and Cardenas (2001),

In a studio environment, students work on semester long open ended projects. The faculty member is more of a facilitator than a lecturer. Student designs undergo multiple and rapid iterations. Work-in-progress is critiqued by peers, instructors, and visitors. Multiple design media is used both to support design activities and to improve student insight and skills. (Kuhn, 2001; Little & Cardenas, 2001 , p 310). Brandt et al. (2013) describe studio learning as a variation of problem-based and project based learning. "The student portray their designs through diverse representational modes: by sketching on paper or by drawing with digital software; through constructing low fidelity prototype; or by building small-scale and even true to scale models" (Brandt et al., 2011 , p. 331) Davies and Elmer (2001) describes modeling as meta-cognitive activity and that a student's presentation of his/her design process (modeling process) allows the externalization of a student's interior thought process about design. Assessment in studio can cover a broad set of indicators (De La Harpe et al., 2009) such as students creativity, design process, ability to act and think like a designer, interdisciplinary skills etc. (p.43). Assessment of student work is mostly formative in nature.

Scaffolding

The studio model has aspects of scaffolding woven in its design. Assistance and guidance, key characteristics of scaffolding, are also essential in studio environment since the learner takes a central role and the instructor acts as a facilitator. According to Puntambekar & Hubscher (2005), since the mid-90s the construct of scaffolding has been considered more broadly and is no longer restricted to interactions between a student and a superior other. The notion of scaffolding now includes peers, artifacts, resources and the environment itself (2005 , p.1). However, it is important to stick to the original theoretical understanding of scaffolding while making claims of occurrence of scaffolding. In this paper we consider the construct of "peer scaffolding". We look for scaffolding attributes exhibited in a studio environment by peers. The scaffolding attributes used in this paper are adopted from Wood et al. (1976), particularly recruiting one's interest, reducing the degrees of freedom by simplifying the task, maintaining direction, highlighting the critical task features, controlling frustration, and demonstrating ideal solution paths, as well as from Putambekar et al. (2005), specifically ongoing diagnosis, dialogic and interactive nature of instruction, fading support, etc. Table.1 provides the operationalized peer scaffolding attributes used in this study.

Table 1: Operationalized definitions of peer scaffolding attributes

Attribute	**Operationalized Definition**	**Original scaffolding attribute from which the definition has been adopted from**
Shared understanding	Peers establish a shared understanding of common goal and provides motivation	Shared understanding (Puntambekar & Hubscher, 2005)
Ongoing diagnosis	When a peer is watching and providing proper prompts to another.	Ongoing diagnosis (Puntambekar & Hubscher, 2005)
Reduction in degree of freedom	When a peer helps another to perform the task by breaking down the problem.	Reduction in degree of freedom (Wood, Bruner, & Ross, 1976)
Marking critical features	A peer asks questions in order to understand why and how the other came to a certain conclusion. This helps students to identify and reflect on discrepancies in the design.	Marking critical features (Wood et al., 1976)
Fading support	A peer initially helps another but gradually modifies his/her role so that the learner is in control and taking responsibility of learning.	Ongoing diagnosis (Wood et al., 1976) (Puntambekar & Hubscher, 2005)
Demonstration	A peer demonstrates a certain task (partially executed) so that the other can learn the task.	Demonstration (Wood et al., 1976)
Frustration control	Peers help each other to overcome frustrating situations.	Frustration control (Wood et al., 1976)

Research Study

Studio based design courses offered by disciplines like industrial design or architecture are good avenues for engineering students to gain design experiences. In this paper we investigate industrial design studio courses offered to students from different disciplines including engineering.

A preliminary qualitative study was conducted in the summer of 2013 in a large land grant university, in the southeastern United States. According to the Carnegie Classification of Institutions of Higher Education this institution is considered as large and a very high research university(Carnegie, 2012).Using ethnographically-informed methods the students and faculty members of an industrial engineering program were observed in during class meeting hours. From a situative perspective the observation notes included what students were doing, how they were interacting with others in the studio, their use of tools etc. Data included transcriptions of observations, interviews, and archival data. Data analysis was guided using a scaffolding framework(Table 1) informed by Wood et al. (1976) and Puntambekar and Hubscher (2005).

Participants for the study came from two courses. One design course and another a sketching course. The design course had thirty students of different majors such as engineering, industrial design, architecture, and liberal arts. The students from this course were designing a customer-based project. The sketching course had nine students. Students of this class were from industrial design, engineering and architecture. In the sketching class students were developing their sketching skills. Only one student was taking both the courses. Seven students were formally interviewed. Students interviewed were from engineering, industrial design, interior design, architecture, and English.

Qualitative field study involves a detailed description of the settings or individuals, followed by analysis of the data for themes or issues(Creswell, 2008). In this paper the researcher first provides a description of the ID program where most of the student activities take place and is considered as the settings. Following the basic description of the settings, the researcher moves to conceptual ordering by organizing data into discrete categories "according to their properties and dimensions and then using descriptions to elucidate categories"(Strauss & Corbin, 1998).

The observers attempted to remain external observers as much as possible, with minimal interactions with participants. The observers took notes in a naturalistic setting. To ensure trustworthiness of observations and analysis, two researchers wrote notes and observations independently, and then consulted with each other afterwards. Observation protocol focused primarily on conversation topics, student behavior, student actions, student interactions, and student-faculty interactions. The observation data from the research sites somewhat informed the student interview protocol. For example, if an interview participant discussed a particular event that the researchers had also observed, the interviewer would bring up that observed instance as a clarifying example. Observations included observations of studio students during typical weekdays, including outside and during course hours.

This preliminary study focuses on answering the following two research questions

1. How do students perceive their learning experience in a summer studio environment?

2. Which attributes of the studio learning environment support students' learning process?

Research setting: ID studio

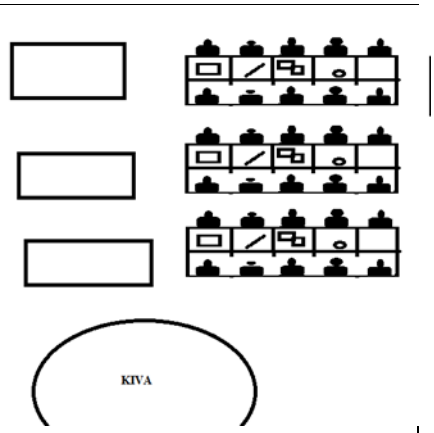
All ID students at this particular University were co-located in a large cafeteria type studio environment. During regular semesters (fall and spring) this space accommodates approximately 400 students. In summer, however the studio looks somewhat deserted since only two ID minor courses were being offered: a sketching class of nine students and a studio design course of thirty students. Another group of students from architecture were also present in the studio. There was a large round enclosed area in the middle of the studio which is called the "KIVA" (it is designed by the firm KIVA ™[1]). The KIVA is used for discussion sessions. The walls of the KIVA were used as a large continuous white board for idea generation and brainstorming. There was a larger meeting table in front of the KIVA. This table is where the students of sketching class met every weekdays from 9 am to 12 pm for 8 weeks. The students of

[1] http://www.maya.com/about/our-space

the design class each had individual desks assigned to themselves and were grouped together along three rows where each faced another. This class met also met every day from 2 pm to 5 pm. Both classes had students from different disciplines, e.g. engineering, liberal arts, English, industrial design, interior design and architecture.

The second floor overlooked the studio and this is where the faculty rooms are located. In the same building, the ID program has computer-aided design (Academies) laboratories and shop facilities. Shop facilities provide woodworking and metalworking equipment; a ceramic workshop allows creative and analytical work with clay and plaster; a graphics workshop includes equipment for etching, embossing, serigraphy, darkrooms and film, video, and other photographic facilities

Sketching class



Design class

Figure 1: Student studio orientation

Students in both classes were working on individual projects. Sketches that they had completed were hung on board just besides where they were sitting. The students of the design class were responsible to come up with a design prototype for a customer company by the end of the semester. The students would pin up their initial sketches/ideas of designs along the walls of the KIVA. Each student presented his own ideas. Some sketches were better than others. The students were casual about their ideas, presented in a colloquial manner. During these sessions, mainly the instructors provided feedback, with some comments from other students. During other class hours students were working on their own at their desk, occasionally walking up to another, talking to the instructors. There were also pieces of equipment, for example a saw, some foam, scales, cupboard and scissors lying around. There were computer stations available for students to use if they needed to draw something in CAD. Every now and then a student would come up to use something. While using equipment or a particular material, another student would come up to assist. Instructors of both classes walked around the students to provide feedback and design suggestions. The nature of interaction between student and teacher, and amongst peers was informal.

Findings

Findings of study reveal that students from different disciplines appreciate their design experience of making something creative. The following section provides a summary of their studio experience and scaffolding attributes that were naturally observed by the researchers.

A different learning experience than traditional classroom learning

The studio model gave students a different learning experience compared to courses they usually take. Students (specifically engineering students) expressed that the studio course gave them an opportunity to make something meaningful and be creative which they rarely get to do in traditional classrooms. Students also mentioned that they had greater flexibility in learning and the prospect to work on their own pace. John described this as

"Just being able to be creative, design whatever you want and not being restricted. ...I really like the studio part of it, being able to work on your own pace and the whole concept behind of it."

Linda described the studio model of learning as being perpetual. When asked how the studio course differed from other courses she had taken, she mentioned the studio environment as being open, result oriented and having a lot of creative freedom. She described that learning was not limited to class duration. Even after class time she was thinking about her project.

When I am in a class [traditional] learning, listening to a professor and as soon as I am done, I just leave. But in this [studio course] it takes a lot more of thought even outside the class. Even if you are not directly working on a project your subconscious is twisting all the gears, trying to figure out.

Tom compared the traditional class work with studio work.

It is very much result-oriented working environment here where you just need to be producing work, sometimes for a project you need to be here twice as long… When I think there is very little creative freedom in other classes even in writing courses, there is very rigid structure how you expected to deliver…But here [studio] the professor likes to be surprised even if you break the rules little bit. In other words, the professors will tell you to acknowledge the rules and then break them.

For Tom the studio also provided an open ended, interest driven, less structured working environment.

Being responsible for one's own learning

In the studio, students are not only responsible to come up with their own designs but are also responsible to develop skills necessary to complete the project. John while explaining his project explained that in order to come up with a good design he had to develop certain skills which were not explicitly taught in class.

One thing about design though is that you kinda have to make it work for yourself…your projects aren't going to build themselves, people aren't going to build projects for you. So you really need get out as much as you want to get out because you can stay in here and learn constantly or use the library, talk to a professor about getting access to the screen printing room or getting in to pottery studio. Even if you were not in class, you're still can get your foot in a door to learn and use that equipment.

Appreciation for theoretical knowledge

Students from other disciplines (e.g. engineering, philosophy) expressed that the studio course helped them appreciate the theoretical knowledge taught in their traditional lecture based courses. The studio design experience also helped them make connections with professional work. Alen expressed this as

In engineering all we have been doing is dealing with I guess the theory behind it, the concepts. This class [studio] is like… It is kind of into the future. Like showing you what you would be doing with engineering. You are making it. And I guess that is making me appreciate it [theoretical knowledge] more …Because it is kind of giving me the confidence to stick through it [Engineering program] because eventually I am going to be doing that kind of stuff …

The studio design experience helped Alan appreciate his own discipline and the need of technical knowledge.

Assessment is based on student's personal growth

In the studio courses assessment of students' progress was formative in nature. Subjective evaluation was provided at the end of the semester. Instructors roamed around providing feedback to students. Not only instructors but peers also critique and provide feedback. Each student is evaluated based on individual improvement during the semester.

Summer studio versus Fall/Spring studio

For students coming from architecture or industrial design the summer studio course was a bit different from their regular studio courses. For Brinda, an interior design major her summer experience was

It's definitely interesting seeing different people. But I can definitely tell our studio is not close like my interior studio because we are all doing the same thing, we are all on the same page, you know spent a lot more time together, but we just get along more.

For Brinda, who is more familiar with the studio environment found it different working in summer. In summer students come from different disciplines including some from a more traditional lecture based learning environment. The difference in the student cohort made her experience a bit different during summe.

I just barely talked with anybody here, everybody is all awkward cause they don't wanna talk to you cause they don't understand what studio is like. I wanna talk to everybody. That's definitely a difference, because they are not used of studio setting. But other than that, it's cool. Really I could see different ideas from different majors from people who haven't studied, you know foundation and whatever stuff, I mean it's cool to see like really different things from that type of backgrounds.

Brinda was more accustomed to being in the studio environment with her disciplinary cohort; however, she did appreciate the interdisciplinary perspectives that the students contributed to the learning environment.

Summary of student's studio design experience

The summer ID studio allowed students to design interest driven individual projects. The design experience helped students to appreciate their own disciplinary knowledge too. The formative nature of assessment and the self-helping culture of the studio forced students to reach out and learn from each other.

In terms learning from each other, attributes of scaffolding is important. Through scaffolding one can achieve a higher level of understanding by way of assistance from a more knowledgeable other(Author, In press).The open structure of the studio environment creates an opportunity for not only instructors but also peers to play a crucial role in assistance. Thus it is worth investigating if pees are exhibiting scaffolding attributes in these studio courses. The literature of learning suggest that scaffolding is not simply assisting. It involves attributes such as demonstration, fading support, marking critical features etc. In the following section we describe peer scaffolding attributes (table 1) noticed in the research setting.

Peer scaffolding in the summer studio

Although student in the summer were not doing group projects still a lot of collaboration amongst peers was noticed. These students did not belong to any particular cohort or discipline. This intrigued the researchers to look into how and why students were collaborating with each other which lead them to the concept of peer scaffolding.

Presence of scaffolding, was determined by naturalist observation of one or more of its attributes in the setting. The researchers of the study noticed shared understanding, marking critical features and demonstration scaffolding attributes being exhibited by peers in the studio courses. The following quotes and observations reveal these peer scaffolding attributes.

Peers have a shared understanding that studio learning is not competitive

The students of the studio courses had the shared belief that they were here to improve their skills and that the environment was not competitive. Lina expressed her shared belief in the following quote

> *It is [assessment] incredibly subjective. It is ridiculous sometimes... each person is graded as themselves. So I would be graded based on where I was when I started the*

class and based on how much I have improved at the end of the class. So it really is for everyone and actually even said today, only thing matters is your improvement … (Linda)

Tom also conveyed the noncompetitive nature of studio environment.

"It's not competition, you know when you look at somebody else's work. You like it or don't like it…I would see them and if it is awesome and really good, let me talk to this person and see what to do… just [to know the] specific way of rendering in art, a type face or something like that. We don't really be competitive because our projects are so different, occasionally we have competitions, but at least in the classes I have been we are not really like cut throating each other trying to win. We are doing what we are interested in…"

Students' priorities here are to learn and improve their skills. Not having written examination and standardized assessments allowed students to work on their own pace and help each other. This lead to a creative collaborative environment rather than a competitive one.

Peer demonstration of "how to do something" helps to mark critical features and control frustration

The open structure of the studio provided students the opportunity to see each other's work.

"… studio is so big that it is spread out so you get to know everyone else that works...I mean in the summer, the fact we had nine people sitting around at one table. We all pretty much were working with each other, I really enjoy that." (Steve)

Although working on independent projects, one would critique each other's work and ask questions.

Generally asking one of my classmates, it is common practice in studio to yell out if you have question, and generally somebody knows the answer (Linda)

Sketches by students were hung around the KIVA and on the bulletin boards. The researchers observed students looking at other works. When they were asked how the public display effected them, they expressed that it helped them understand different aspects students were approaching a single problem and would evaluate their own work. Since the environment was not competitive, students were ok to display half formed or rough sketches. Discussions with peers and public display of everyone's design helped students to mark critical features and control their own frustration.

Demonstration and fading support are other key scaffolding attributes. By showing someone how to do a task and then gradually letting the person do the task on his own portray such behavior. While demonstrating it is necessary for the tutor to break down the task into smaller steps so that the tutee can gradually be able to do the task independently. The following vignette reveals scaffolding attributes demonstrated by Alen.

Students from the design course had to develop a prototype of their design. Jessica, who had no previous experience in cutting and shaping foam was apparently struggling with a saw and a piece of foam. Alen had been noticing this for quite some time. After a while he came up to Jessica. He showed and explained how to angle the saw and place the foam on the table. After demonstrating and elaborating the process Alen allowed Jessica to do the task on her own. Alen stayed close by for some time. Eventually once Jessica had a grip on the task Alen went onto doing his own chores.

Although it might be common in team projects for students to assist each other, in this study all students were working individually and still we see students helping each other. Judy during her interview mentioned,

"I mean we work by ourselves but at the same time you get to interact with other students, I have a lot of people in my class who I go to and ask 'Is this a good design? Is there any feedback?' The main part is to get feedback from other students. Because I mean you may have an idea that you think is really good and design going to be, it turns out really well. You can go to someone else and they have a completely different view on it and .., I guess it strengthens you, your skills helps you to be a better designer."

Judy's quote suggests that the studio environment provided students the opportunity to seek feedback from others which helped students to mark critical features and stay on course.

At times even though a student is not intentionally showing another how to do a task, simply by observing someone else doing a task can help students.

"Definitely, looking at what other people are doing and getting a sense of where they are at. So in a way, the cultural dynamics of the studio can affect how well people do collectively ..."(Anderson, Courter, McGlamery, Nathans-Kelly, & Nicometo)

Tom's quote also portrays how seeing peer work helped students control their frustration. Scaffolding attributes like shared belief, ongoing diagnosis, and demonstration were the themes that were noticed prominently in the data set. Attributes like fading support, marking critical features, reduction of degree of freedom and frustration control were not perceptively demonstrated by peers.

Discussion

"Design projects have been used as vehicles to motivate and integrate learning" (Dym et al., 2005, p. 109).Teaching environments should provide better transformative opportunities of information delivery, demonstration of techniques and practice of disciplinary work that better prepare students for the complexities of professional practice(Brandt et al., 2011).According to Brandt et al. (2011) the studio method has effectively been used in different disciplines for students working on design projects grounded in the realities of professional practice. The findings of this paper align with the attributes of the studio literature. The summer studio experience was not only exceptional for students coming from non-studio learning environments (e.g. engineering, English, philosophy) but also for students coming from a studio environment

who had the opportunity to interact with peers from other disciplines. Creative freedom, informal interaction with peers and instructors, the non-competitive nature of work, individualistic approach of learning, all which are major attributes of the studio method, came out unsurprisingly from interviews and observations data. Brandt et al. (2011) also suggest that although the instructor mostly guides the pedagogy in a studio environment, "students too can introduce pedagogical activities through peer mentoring or when introducing unexpected resources to illustrate one's thinking for their peers and instructor" (p.333). It is this particular aspect of peer assistance that we further investigated.

In terms of scaffolding, the results of the study indicate that peers provide an important role in studio courses. Although students were working on individual projects, scaffolding attributes and processes, such as shared understanding, ongoing diagnosis and demonstration were revealed. The studio environment provided a shared understanding of a collaborative rather than a competitive learning environment. Students were comfortable and willing to share half-formed ideas and projects with each other. Engineering students particularly valued this. The open studio structure provided ongoing diagnosis and direction for students. Peers openly interacted with each other, critiquing sketches and design ideas, and providing each other information on alternative resources one may seek. Projects and sketches of students were hung in open spaces. The seamless interaction between peers helped students to overcome their frustrations and confusions in courses that offer limited formal assessment. According to Lai and Law (2006), there is the need for inequality in competence between individuals for scaffolding to take place. The difference in disciplines of students in the studio courses in summer created such an enabling peer-scaffolding environment. Students with particular skill sets were seen helping students from other disciplines learn that particular skill.

Limitations

Although the results of the study reveal several positive outcomes, most of them significantly depend on the individual him/herself. The heterogeneity in the observed sample also had some role to play in peer scaffolding in this setting. It can be generally assumed that all providers and all recipients (students) of peer scaffolding would not show the same level of response. Some peers would be more forthcoming than others in helping. Also, all students would not be equally responsive to such offer and opportunities of scaffolding. It is worth investigating students who (eg, because of his shyness) did not avail scaffolding vs. someone who availed more than one services. Also, the conditions to improve the quality of peer scaffolding need to be further investigated. This preliminary study was conducted during a single summer semester, however the results will inform a full-scale study on additional summer sessions, which will provide more thick descriptions/vignettes of peer scaffolding attributes in studio-based design courses.

Conclusion

Overall, the studio courses were perceived by the students to be a valuable experience. Peer scaffolding appeared to play an important role in studio learning environment. This research helps identify peer-scaffolding characteristics in an innovative engineering learning site that moves away from traditional curricular pedagogy. Further in-depth researches are needed with

more appropriate samples having focus on discerning the impact and significance of different scaffolding attributes on learning outcomes.

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