Integrative Learning in a Synthesis and Design Studio: A Phenomenological Inquiry

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Abstract - Engineering education is uniquely qualified to make strides towards both a more integrated curriculum and understanding the benefits of an integrated learning experiences, due to the vast amounts of experience with innovative integrative curricular structures. This paper briefly describes an innovative approach to integrate student learning through a four year Synthesis and Design Studio. This provides the context for a phenomenological research study that investigated the nature of students’ integrative learning processes. More specifically, the study examined integrative learning through the lens of students’ experiences of the focus on deliberate reflection and engagement in the authentic interdisciplinary setting during an interdisciplinary Studio offered in the Fall of 2009. This study consisted of the interpretive analysis of individual reflection reports written by each student after participating in a range of reflective activities over the course of the semester. In addition, the qualitative data included open-ended responses collected from a mid and end-of-semester survey that was conducted externally. The phenomenological analysis of the students’ experiences suggests that their development of a professional way of being as a key aspect of integrative learning that emerged gradually from the complex influences of the interdisciplinary educational experience and can be fostered by deliberate, continuous reflection.

Index Terms – Authentic interdisciplinary experiences, Curriculum integration, Deliberate reflection, Synthesis and design studio, Phenomenology

INTRODUCTION

In today’s rapidly changing world that is becoming more connected there is a critical need to provide opportunities for students to integrate their learning across disciplinary aspects as well as in the technical and non-technical facets of their professional development [1]. Prior thinking that knowledge is created in disciplinary silos is becoming more and more outdated—instead knowledge is considered to be created at disciplinary interfaces [2]. It is, however, “difficult to incorporate [integrative learning opportunities] into the undergraduate experience because the normal structures of academic life encourage students to see their courses simply as isolated requirements to complete” [3].

Unfortunately there are many obstacles to integrating the curriculum including the course and credit system, the design of curricula being focused on courses instead of vision, and the divide between general education and major requirements [4-5]. However, engineering education has made large strides towards an integrated curriculum with first year and senior year design experience [2, 6-7]. This development occurred in spite of the trend towards including more engineering sciences within engineering curricula that began after World War II [8]. In 1967 Jay Forrester explained that, “Engineering has become preoccupied with its science and fails to focus on the more fundamental objectives of bridging between isolated compartments” [9]. This struggle between including more engineering sciences in the curriculum and providing more opportunities to integrate learning is particularly prominent when designing and implementing a new curriculum as is currently occurring in the environmental engineering program at the University of Georgia.

CONTEXT—THE STUDIOS AT UGA

The following briefly describes the development of the new curricular structures and a Synthesis and Design Studio series as an innovative approach to curriculum integration. This provides the context for the empirical investigation of fundamental processes of integrative learning. With this focus on qualitatively exploring this aspect of student learning, this paper is not aimed at evaluating effectiveness or perceptions of the course (for more information see: [10-11]).

In 2001 the Faculty of Engineering was established and a think tank was formed to create a vision of engineering at the University of Georgia (UGA). This think tank included faculty, students, staff, and administrators from engineering, visual arts, geography, pharmacy, and biology and developed a vision of “engineering in a liberal arts environment,” where graduating engineers are humanistic, innovative, and technically excellent. Soon after this vision was devised, the first three engineering undergraduate programs were approved in environmental engineering, computer systems engineering, and biochemical engineering and faculty quickly began designing curricula for each of these programs.

In order to achieve the vision of an innovative, humanistic, and technically excellent engineer, the design of the new curricula was focused on how to integrate students’ experiences across the curriculum, the students’ lived experiences, and the students’ prior experiences. In the environmental engineering curriculum, faculty leveraged...
traditional program structures to foster technical excellence in the students. However, new curricular structures were needed to achieve and integrate the humanistic and innovative aspects of the desired graduates. The curricular innovation that was created was a four year series named the Synthesis and Design Studios [10].

This series is based on a studio approach [12] and is threaded throughout all four years of the environmental engineering curriculum while including at least one interdisciplinary Studio, a development that was informed by other interdisciplinary programs [13]. These Studios are specifically modeled after the graduate-level studios that have been implemented in UGA’s Educational Psychology and Information Technology department over the last 10 years [12, 14].

The main objective of the Synthesis and Design Studio is for students to develop a deep understanding of the larger socio-technical systems in which engineering is situated. Throughout the four years, students will develop an understanding of the interrelationships between engineering, the social sciences, and humanities. Our premise is that as a result of the Studio Series, students will become systems thinkers with the ability to think holistically as well as reductively in order to be prepared to deal with the complex issues that the students will be facing in their careers.

For the first implementation of the Studio in fall 2009, it was decided to collaborate with art for the potential synergistic possibilities as both disciplines have a significant design component. The Studio consisted of ten art students (mostly juniors and seniors) and nine engineering students (freshmen with a few transfer students), an opportunistic choice that was forced by the requirements of the curricula of the respective disciplines. The Studio was co-taught by two faculty from engineering and one from art and met twice a week for three hours per session. These Studios were significantly different from typical courses encountered in the engineering or art curriculum in that they provided the interdisciplinary student teams with socio-technical design challenges in which students from both disciplines could contribute to problem framing and problem solving on an even footing.

RESEARCH FOCUS AND QUESTIONS

Within this studio environment, student’ experiences of two particular pedagogical features, (i) deliberate reflection and (ii) an authentic interdisciplinary experience, provided the lens for the investigation of fundamental processes of integrative learning presented here. These pedagogical features were selected for their potential to provide an integrating influence on students’ learning and thus provide a rich context for examining the nature of such processes.

Deliberate Reflective Activities: Fostering reflection is increasingly recognized as playing a central role in student learning [15-17]. In the Studio multiple opportunities for reflection were intended to help students establish connections between various aspects of their learning.

Authentic Interdisciplinary Experiences: The course was based on the conception of interdisciplinarity as a genuine engagement with the ways of thinking of another discipline as in the synthesis of art and engineering [18-24]. The above-mentioned socio-technical design challenges, for example, explicitly connected materials across the curriculum and across students’ education, life, and prior experiences to provide them with opportunities to integrate these aspects of their educational experience.

The empirical investigation of integrative learning through the lens of the pedagogical features described above aims at exploring some of the influences and mechanisms by which students synthesized otherwise disparate aspects of their learning. More specifically, the qualitative research addressed the following questions:

• What are ways in which the students experienced the pedagogical features of deliberate reflection and the authentic interdisciplinary experience? And based on this analysis,

• how did these experiences contribute to the integration of both disparate aspects of students’ learning and their prior as well as current life experiences?

METHODOLOGY

The research questions were addressed in the context of a larger case study of the interdisciplinary Studios that investigated a broad range of aspects of interdisciplinary learning and creativity [10, 25]. The investigation of integrative learning presented here draws on reflection reports in which students described critical learning and development experiences during the semester and was triangulated through qualitative data from an external survey of the students’ experiences in the course.

I. Student reflection reports

A core intention of the Studio course was to explicitly foster students’ reflection on their own learning and development. To overcome some of the difficulties associated with deliberate reflection [26], the Studio introduced a range of strategies to develop students’ reflective capacities over the course of the semester. These strategies included a reflective, visual journal, short reflective writing activities, and reflective focus groups with six to eight students [27-28]. The focus groups, based on critical incident techniques [29], were conducted three times during the semester and each was followed by a written component to provide students with the opportunity to systematically make sense of the critical learning experiences that were elicited in the focus groups. The progression of these reflective strategies culminated in an individual reflection report that asked students to draw on earlier records of their reflection and synthesize these events in the sense of an overall learning development. Due to their retrospective character, these reports potentially capture a broad range of accounts of integrative learning processes and were thus used as a data source in this analysis.

II. Course evaluation

Two surveys of students’ experiences in the course were conducted by an external evaluator team at the midpoint and
the end of the semester. The surveys contained closed and open-ended questions that examined student expectations, satisfaction and explored aspects of the students’ perceptions of their own learning. The mid-semester survey approached these aspects broadly, asking students, for example, to elaborate on their perception of crucial aspects of their learning in the course. The end of semester survey assessed the students’ overall satisfaction with the course and further explored themes that had emerged from the students’ earlier responses. For the purpose of triangulating the student accounts in the reflection reports, this study considered the open-ended survey items that asked students to describe, for example, their personal and professional development over the entire semester. These responses were imported into the qualitative data analysis software NVivo 8 to be coded together with the student reflection reports.

III. Analysis

The data analysis followed a phenomenological approach [30] whereby the students’ shared lived experiences of the two pedagogical features were explored through the data. The aim of the analysis was to understand shared features of how students experienced the focus on deliberate reflection and the authentic interdisciplinary experience. At the same time the iteratively emerging codes captured how the students perceived and made sense of these experiences.

The data analysis using the qualitative software tool NVivo 8 was conducted in an interdisciplinary research team. In a first iteration, topic codes were developed to capture themes in the students’ accounts of the two pedagogical features thus representing the “experience-near team. In a first iteration, topic codes were developed to capture themes in the students’ accounts of the two pedagogical features thus representing the “experience-near constructs of the participants” [31]. In the sense of a phenomenographic analysis this stage of the research focused on discerning textural and structural patterns or features in the data [30]. Textural patterns refer to codes that capture ‘what’ the respondents experienced with respect to the two course features under investigation. Structural descriptions refer to shared features in the participants’ descriptions of the conditions, situation and context, in short, ‘how’ they experienced the phenomena of interest. In developing these codes iteratively, methods of constant comparison [32] were employed to delineate and define the categories. The results of this gradual abstraction from the students’ experiences are presented in the coding clusters and categories in the section below.

After negotiating these codes within the research team, the interpretive analysis proceeded to general patterns of integrative learning that emerged from the consideration of the participants’ multiple perspectives. More specifically, this step of further abstraction was based on the combination of the textural and structural descriptions in order to derive general aspects of integrative student learning. Some of the aspects of this higher order interpretation inform the discussion section that explores the integrative influences of deliberate reflection and an authentic interdisciplinary experience on student learning.

RESULTS

The following outlines the textural and structural descriptions for, first, the students’ experiences of the deliberate reflection in the Studios and, second, for their accounts of the authentic interdisciplinary experience. Each section gives a brief, narrative overview of the coding structure (clusters and categories in italics) to then focus on specific categories that provide a particularly illuminating perspective on the nature of the integrative learning processes.

I. Deliberate reflection

Students’ accounts of their experiences of the reflection focus in the Studio capture a range of reflective activities comprising the prompted reflection in their journals, reflective writing exercises, and focus groups. In addition, codes emerged for unprompted reflection (outside class, in class) and synergies between the various forms. The clusters and codes for the structural descriptions (‘how’) captured ways in which students experienced the process of reflection (e.g. sudden realization, gradual processes, degree of intentionality). This was complemented by emerging clusters for the types of transformative events that triggered the reflection and the kinds of emotions that caused or accompanied the reflections. Beyond these descriptions of the ways in which reflective insight emerged and was experienced by the students, other categories captured the context in which the reflection occurred in terms of influences and the perceived benefits. The following paragraphs present “thick descriptions” [33] from the data to focus on the interplay of prompted or unprompted and sudden or gradual reflection that was observed in the data.

A shared theme in the students’ accounts of their experiences of reflection in the Studio was the connectedness of prompted reflection through the reflective exercises described above and the unprompted reflection at other times. For most participants, these aspects were inextricably linked as described by Robin, a male engineering student:

“My second ‘AHA’ moment came when we were doing our last focus group discussion. As we were discussing this topic and I was able to voice some of my thoughts something else hit me. Engineers and artists are trained in two completely different directions.”

He describes how the stimuli provided in the reflective focus groups led to insights in a different area of his learning. More specifically, the intentional reflection led to further unintended reflective insight about the nature of the interdisciplinary experience. Rene, a male engineering student, similarly described his development of an appreciation for the interdisciplinary nature of the course outside a prompted reflective activity:

“At the beginning of the class, I didn’t see how art students and engineering students related to be in the same class. My view has definitely been changed and I feel it is a great
idea for a class. "Sparks of Genius" brought the idea of the two fields being closely related very clearly."

In this case, the realization was not attributed to a particular moment but the student identified the class reading [34] as one of the transformative influences.

In a similar way that prompted and unprompted reflective insight are connected and give rise to one another, the sudden or gradual nature of the processes was described by the students as closely linked. Robin expressed this explicitly:

“The experience that I am going to talk about is really a conglomeration of experiences that led to at least two ‘AHA’ moments."

Elaborating further on this interplay of sudden realization and gradual insight, Jo, an engineering major, described:

“I had a huge realization that this project is a work in progress. [...] I never grasped that concept before. Each time something was due or being presented, I always wanted to finish it. One day in class, someone said [that] it was really good we had kept to a broad idea and not gone too specific. Then we were graded on our in-process critique and did well. I then realized that I did not always have to finalize all ideas and tie up all the loose ends.”

In this case the student was able to observe how established thinking patterns of his had been challenged in the process of working on the open-ended projects in the Studio. These processes culminated in a transformative moment (grading of in-process presentation) where the gradual changes became explicit and the student was able to articulate his learning with respect to tolerating ambiguity and resisting closure in a problem solving process.

The above examination of the relationships between gradual and sudden, as well as prompted and unprompted reflection suggests a complex interplay of these processes. For developing students’ reflective capacities in a course setting it thus becomes clear that educators need to provide students with a range of stimuli for reflection and introduce different approaches and tools. One reason lies in the fact that not all students’ respond equally to a particular approach. More importantly, reflections elicited in different activities can together lead to the emergence of higher level insight. In a similar way the analysis of the data suggests that a continuous approach to reflection is required. A single event during a semester does not lay the foundations for the gradual realization processes observed here, neither does it provide the necessary practice to develop reflective capacities.

II. Authentic Interdisciplinary Experiences

Students’ accounts of their experiences in an interdisciplinary learning environment were coded as textural descriptions (‘what’) of curricular structures (projects, readings, reflections, and in-class activities) and emergent interactions (peer interactions, peer observations, and team interactions). Moreover, students’ reflections and evaluations were coded for structural descriptors (‘how’). These structural descriptors included emotions that students experienced in this interdisciplinary learning environment (anxiety, excitement, and trust). This was complemented with descriptions of the processes that enabled a significant learning experience to occur. An example of these processes is the redundancy of certain aspects of the course, the perceived slowness of the team projects, and the gradual familiarity with different ways of thinking and being. Finally many students explained personal theories and conceptions of the connections of art and engineering and of different ways of thinking (e.g. creativity and diversity).

The following paragraphs present ‘thick descriptions’ [33] from the data to focus on the role of the team in this interdisciplinary experience and how trust emerged as a critical aspect that led to interdisciplinary learning experiences.

A common theme in students’ accounts of their experience of interdisciplinary in the Studio was the critical role that the team and peer interactions played during in-class activities and project work. For most students the in-class activities (e.g. art making, body sculptures, debates, and engineering challenges) provided a space outside of the higher-stakes project to explore different ways of thinking as common in art and engineering. Taylor, a female art student, described one of these activities and its benefits:

“I feel that one way we always seemed to come to a consensus throughout the semester was through group artistic expression. In these cases I was usually allowed to express what I was thinking visually and we all seemed to react to this well [...] We [...] did this piece as a team. It was through these processes that I learned that in the end we can and will come together with great ideas[...]. I will be sure to use this sort of creative thinking for future group work and brainstorming.”

Taylor describes how these in-class, group art-making activities led to coherence and creativity. Moreover, she describes how she will use what she learned in this team process to apply to other group work.

Similarly, Rene, a male engineering student discussed the importance of having art students on his team and how this helped him realize his way of thinking as an engineering student and how this contrasts with the artist students’ ways of thinking.

“Without the influence of the art students our project would have gone in a much different direction[...]. As an engineer, I tend to get caught up on a one way road and not get as completely creative as possible[...]. I have realized that artists think about things with an open mind to any form of representation. I usually have an idea pop into my mind and go with it, using formulas and theorems.”

Rene reflected back to a particular milestone in the project in which the students were required to submit a report. Through peer interactions while working on their report, Rene experienced new ways of thinking and experiencing the world—a genuine interdisciplinary experience.

From the students’ discussions of the team and peer influences in their interdisciplinary learning experience trust emerged as a critical precursor to effective collaboration in interdisciplinary teams. Most students described or...
specifically mentioned trust in their reflections of the course and in the evaluation surveys. Sam, a female art student, explained her experience when participating in a debate [35] and explains how this experience provided clarity to her team’s dynamic:

“I fully trusted my teammates to do a great job because I had seen them perform in other projects throughout the class […] it was exciting to have a team I was proud of and trusted. I remembered that I did not have to take on everything and was thankful I had already recognized that I needed to trust my own team members more.”

Sam’s reflection describes a theme common in the data emphasizing the importance of trust when working in a group. This focus on trust suggests that it is critical to establish trust in teams and especially in interdisciplinary teams. The in-class activities with low-stakes activities (as opposed to larger projects with higher stakes) may have provided a critical space to help students realize the importance of this trust. Alex, a female engineering student explained that this trust among students and between students and their teachers was critical in providing motivation:

“When we all sit down to collaborate and brainstorm, I feel like I get a good idea of how everyone is feeling […] It’s fun because I can instantly tell when someone agrees or disagrees with something purely based on their body language. It makes me feel good that I have a sense of how everyone is…This class gives us an opportunity to get to know our classmates, our teachers, and ourselves more than most college courses. I think that this is a positive aspect […] because it makes everyone, myself included, more willing to work hard.”

As Alex explains, this trust and coherence is critical not only for having a productive team dynamic, but it helps provide intrinsic motivation to work hard in the Studio.

Examining the role of teams and trust among classmates brings attention to the importance of the curricular design in fostering a space that is conducive to personal support and trust. Through both low and high stakes activities and projects there was opportunity for students from diverse backgrounds to build a sense of trust and an environment in which they could reach accomplishment. While the incidents described by the students cannot be ‘designed’ into a curriculum, multiple projects and activities can be included that allow for trust to emerge which leads to an authentic interdisciplinary learning experience as described by the students in this Studio.

**DISCUSSION**

The previous section outlined shared features in the students’ experiences of reflection and interdisciplinarity in the Studio. The overview of the coding categories for textural (what) and structural (how) descriptions of the students’ shared lived experiences of the course was combined with detailed analyses of student quotes in key areas. Together the codes and the rich detail provide a authentic view of the overall experience of the participants.

Beyond this authentic understanding, the focus on particular aspects of the students’ accounts provides an illuminating perspective on the nature of integrative learning processes. The discussion of the student quotes from the reflection cluster suggested the need for a varied and continuous approach to fostering student reflection. The analysis of the respondents’ experience with respect to the interdisciplinary nature of the Studio pointed to the need for a combination of low- and high-stakes activities and projects to allow ample opportunities for the students to develop mutual trust and an appreciation of the other discipline.

On an abstract level, both developments constitute gradual learning processes with complex patterns of multiple influences. The above discussion of René’s account of gradually developing insights with respect to the nature and relationship of the two disciplines also demonstrated that both reflection and development of an interdisciplinary appreciation are closely linked.

This combined view on reflection and interdisciplinarity brings attention to the role of students’ development of a holistic, “professional way of being” [36] as one of the key aspects of integrative learning that emerged from the analysis of the data. For the students to genuinely integrate an appreciation of other disciplinary viewpoints into their professional persona is a gradual process that takes place not only on the level of learning content and concepts but also requires a deep personal development process. This development process or the transformation of the interdisciplinary appreciation from an “espoused theory” into a “theory in action” [37] emerges from the combination of multiple authentic experiences and needs to be supported by guided, deliberate and meaningful reflection that transforms experience into learning.

**CONCLUSION**

After outlining the design and implementation of an interdisciplinary Synthesis and Design Studio with art and engineering students, this paper describes a phenomenological study of two key pedagogical features of the course. The focus on deliberate reflection and the authentic interdisciplinary experience were examined through students’ multiple perspectives. The analysis of the reflection report and open-ended survey data yielded shared structural and textural features in the students’ experiences of the pedagogical features.

The discussion of the codes and student quotes in the reflection cluster focused on the complex interplay of sudden and gradual as well as prompted and unprompted reflection. The examination of the students’ experience of the interdisciplinary aspect highlighted the combination of interdisciplinary team experiences with the emerging personal trust between students that was fostered through both the educational design and the tacit learning environment.

In combination the analyses of the student experiences of the two pedagogical features provide an interesting perspective on the nature of integrative student learning.
prominent aspect that emerged across the data concerned students’ development of a genuine appreciation of other disciplinary viewpoints as part of their professional way of being.

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