Reflective Journals: An Assessment of a Vertically Integrated Design Team Project

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Abstract: The use of affective/associative reflective journals and skill-based reflective journals as assessment tools of undergraduate chemical engineer students' learning in a vertically integrated team design project (VITDP) is the focus of this exploratory study. Participants from a large midwestern university were required to submit a reflective journal each week over a five-week period. The reflective journals of 23 participants were analyzed to unearth the conceptual descriptions of teamwork held by the participants, to describe the role of metacognition in reflective journal writing, and to determine how reflective journals facilitate construction of knowledge. Thus, reflective journals were meaningful as assessment tools because they communicated how VITDP participants learn and supplied valuable information to make future curricular and instructional decisions. Based on the reflective journals, teamwork is a social environment in which to learn engineering content and skills; however, the participants did not engage in metacognition. The authors suggest that future VITDP include structures to facilitate synergy and participants need instruction in reflection and metacognition as learning tools.

I. Introduction

The Vertically Integrated (by class rank) Team Design Project (VITDP) is an engineering design curricular and instructional project for the National Science Foundation-funded Bridges for Engineering Education (BEE) project at The University of Akron. The curricular focal point of this project is engineering teamwork. Instruction is accomplished by having the participants, as members of a team, address an engineering design problem written by the chemical engineering faculty. Specifically, the participants are undergraduate chemical engineer major students, but the BEE project is also a curricular and instructional project for early childhood education major students. The vertically integrated team, for this exploratory study, consists of senior, junior, sophomore, and freshman undergraduate chemical engineering major students; however one team includes a graduate non-licensed secondary school education major.

This paper is about the assessment of undergraduate chemical engineer major students' learning. Specifically, we discuss the use of affective/associative reflective journals and skill-based reflective journals as assessment tools. Journals are one mechanism for the observation and interpretation of cognition (Alderman, Klein, Seeley & Sanders, 1993; McCrindle & Christensen, 1995; Newton, 1991). Reflection serves as a means to increase what students learn and also how they learn and can use their knowledge (Swartzenruber-Putnam, 2000). Thus, through reflective journals, the focus of the assessment is concerned with what students know about teamwork and how students use teamwork to solve an engineering design problem.

Knowing What Students Know (National Research Council, (NRC, 2001) dictates that the assessment of a curricular and instructional methodology, such as the VITDP, must focus on "a model of student cognition and learning… a set of beliefs [conceptual framework] about the kinds of observations that will provide evidence of students' competencies, and an interpretation process for making sense of the evidence" (p. 44). For this study, the model of student cognition and learning is constructivism, the contemporary view of learning (NRC, 2000). The conceptual framework includes the set of beliefs concerning constructivism, metacognition, teamwork, and engineering design. The reflective journals are the observations that provide evidence. This paper reports on an exploratory research assessment project that concentrates on the assessment of student learning during an engineering design project through the use of reflective journals.

II. Conceptual Framework

The conceptual framework for this exploratory study consists of four suppositions. Each of these suppositions influences the purpose, design, and analysis of the study.

1. Epistemologically, the learner constructs knowledge. The meaning that is usually constructed is different between individuals and most often different from the intended meaning that the instructor, in this case, the authors, wishes the participants to make.
2. Metacognition involves personally preferred cognitive strategies that "translate personal experience to transferable learning" (Brown, 2001, p.33) and is the "ability to recognize the limits of one's current knowledge, then take steps to remedy the situation" (NRC, 2000, p. 47).
3. Teamwork is radically different than group work. Specifically, teamwork demands that the individual student brings a unique person to the team and through interactions within the team, the team constructs knowledge which is often not owned by any one individual and is different than the knowledge of one individual.
4. Engineering design is a unique process that is fluid and organic, however specific components are present within all design processes.

II.A. Constructivism

Humans are active meaning makers. "The contemporary view of learning is that people construct new knowledge and understanding based on what they already know and believe" (NRC, 2000, p. 10). In other words, "the learner pulls from previous experiences, applies this knowledge to new experiences … juxtaposes old and new experiences, and then constructs or reconstructs a personal understanding (Blake & Blake, 2000, p.831). Radical constructivism, as a way of thinking about knowing, assumes "that knowledge, no matter how it is defined, is in the head of persons, and that the thinking subject has no alternative but to construct what he or she knows on the basis of his or her own experience (von Glaserfeld, 1995, p. 1). On the other hand, "social constructivism emerges out of radical constructivism and is concerned with the contributions of social interactions to the construction of self" (Atwater, 1996, p. 827). In other words, "mental activity is the result of social learning, of the internalization of social signs, and of the internalization of culture and of social interactions" (Blanck, 1990, p. 44). Thus, epistemologically, knowledge and understanding are personal but socially constructed by the learner.

II.B. Metacognition

If metacognition is the process of monitoring understanding (NRC, 2000), "metacognition is crucial to effective thinking and problem solving and is one of the hall marks of expertise in specific areas of knowledge and skill" (NRC, 2001, p.4). Newton (1991) posits that metacognition is both affective and associative. The learner must first have knowledge of and become aware of one's own cognitive processes and have the ability to actively control and manage the processes (Flavell, 1976). Furthermore, metacognition is related to knowledge of person characteristics, task characteristics and strategy characteristics (Flavell, 1979). Personal knowledge includes self-knowledge, knowledge about others and knowledge about the universe – the nature of all human thinking. The learner uses one's understanding of task to guide the approach to the task and the learner will select, execute, monitor, and control the use of cognitive strategies (Flavell, 1987). Cognitive strategies include sense-making, self-assessment, and reflection (NRC, 2000).

II.C. Teamwork

A team is a synergistic group that uses an agreed upon process to reach an agreed upon goal. The critical aspects of this definition are consensus and synergy. This definition is consistent with that of Katzenbach and Smith (1993), whose work was cited by Levi and Slem (1995). In order to reach consensus a team must establish an effective communication plan, a task that is more difficult when team members are not at the same location. Furthermore, the communication between team members must be based on openness, trust, and fairness. As a result, there should be little or no criticism of people on the team. Identifying the strengths of each team member and then capitalizing on those strengths achieves synergy. Rather than splitting up tasks or responsibility arbitrarily, the

team should determine the required skills to handle the responsibility and delegate accordingly. An important aspect of this approach is that consensus is reached on how the tasks are handled with input from different perspectives.

When deciding whether to use teams, one should consider the complexity of the problem. Cohen (1994) reports that what is suitable work for teams is not calculations which could be done by an individual given enough time, but rather tasks that require brainstorming different options, deciding how to apply what they have learned to a problem, participating in role-playing situations, reviewing another's individual work, working through difficult concepts, or explaining problem areas to one another (St. Louis, 2002). Most calculation-intensive engineering courses, particularly lower-level engineering and science courses, promote working in groups and while this collaborative-learning process leads to a higher retention of concepts, it is not effective for teaching teamwork. In fact, over-dependence on group work may undermine the learning of effective teaming skills in capstone design courses, in that the cost of learning new skills (Atherton, 1999) (i.e. changing their ways), may supplant the learning of essential teaming skills.

II.D. The engineering design process

The Accreditation Board for Engineering and Technology (ABET) has defined engineering design as the process of developing a component, system, and/or complete process for solving a particular problem or meeting a need. The engineering design process involves seeking a practical recommendation/solution that is constrained by and may need to be optimized relative to issues such as cost, safety, environmental impact, geographical location, intellectual property, aesthetics, public opinion, and time. The engineering design team must decide how to utilize its resources in order to provide a solution or recommendation that satisfies these types of constraints. The steps in the engineering team design process include forming a balanced team, establishing a communication plan that facilitates reaching consensus, setting a detailed project work plan, utilizing resources effectively to stay on track, and communicating the results in oral and written format.

III. Purpose

Newman, Ridenour, Newman, and DeMarco (2003), when establishing a typology of research purposes, posit the purpose of research directs the study more so than the research question. Therefore the purpose of the study is to determine the usefulness of reflective journals as an assessment tool. Specifically, reflective journals are a means to determine what students know and are able to do concerning the learning and working in engineering design teams.

Also, constructivism epistemologically suggests Ausubel, Novak, & Hanesian's (1978) assertion that what the learners already know may well be the most important factor

influencing learning. Therefore, an additional purpose of this exploratory study is to assess the naïve concept of teamwork held by members of the VITDP. Naïve concepts are those personal theories and beliefs about how things work that we bring to a learning situation. The personal theories and beliefs are "the product of our first-hand experiences, common sense, what we have been told by others, media, books, and instruction" (Stepans, 1996, p. 3) and most often these personal views do not coincide with expert thinking.

As this purpose addresses "why the researcher is undertaking the study" (Newman, et al, 2003, p. 173), we seek to understand complex phenomena or to "delve below the surface of the phenomena, this is …to understand the meaning of the phenomena" (p. 179), namely the VITDP. In other words, the purpose of this exploratory study is to unearth what students know and can do as recorded in reflective journals.

IV. Research question

While participating in the VITDP, "what are the conceptual descriptions of teamwork reported in formative reflective journals?" serves as the research question for this exploratory study. Enabling questions include:

1. How do VITDP participants engage in metacognition as they record reflections in a journal?
2. How do reflective journals facilitate construction of knowledge?

In light of the purpose, the research question implies teamwork is a unique phenomenon that the learner constructs and negotiates both individually and socially.

V. Methods

V.A. Research Design

The purposes and conceptual framework of this exploratory study allude to a naturalistic paradigm for the research design. Lincoln and Guba (1985) define five naturalist axioms: (1) realities are multiple, constructed, and holistic, (2) knower and known are interactive, inseparable, (3) only time- and context-bound working hypothesis (idiographic statements) are possible, (4) all entries are in a state of mutual simultaneous shaping, so that it is impossible to distinguish causes from effect, and (5) inquiry is value-bound (p. 17). Hence, the research design is qualitative. Qualitative research implies and stresses "the socially constructed nature of reality, the intimate relationship between the researcher and what is studied and the situational constraints that shape inquiry. Such research emphasizes the value-laden nature of inquiry. They seek answers to questions that stress how social experience is created and given meaning" (Denzin & Lincoln, 2000, p. 8).

V.B. Setting

The University of Akron is the setting for this exploratory study. The university is an urban institution of higher education located in a metropolitan area. As a public institution, the university has open enrollment. The following descriptive information is for the Fall 2002 semester in which the exploratory study was conducted. The undergraduate student body is approximately 21,000 students or 83% of the students at The University of Akron where the average age of an undergraduate is 25 years of age. Eighteen per cent of the undergraduates are non-white students. The University of Akron awards financial aid to 87% of the undergraduate students. The student population of The University of Akron is a commuting population where 11% of the undergraduate students reside in university housing and 80% of the undergraduates graduated from high schools in Ohio.

The university consists of 9 colleges and schools. There are five departments within the College of Engineering of which the Department of Chemical Engineering is one. Of the 1,600 students in the College of Engineering, approximately, ten per cent of the students are non-white students. For academic school year 2002-2003, there are 10-tenured/tenure track faculty members within the Department of Chemical Engineering. Three-tenured/tenure track professor participated in the VITDP. The Accreditation Board for Engineering and Technology (ABET) accredits the chemical engineering program at The University of Akron.

Also, one tenured faculty member from the College of Arts and Sciences, Department of Physics, facilitates the VITDP. All chemical engineering majors are required to take a sequence of physics courses. Also, a tenured faculty member from the College of Education, Department of Curricular and Instructional Studies, facilitates the VITDP. This faculty member is a content specialist in Early Childhood Education (age 3 years to 3rd grade). Although Early Childhood Education major students are not required to take an engineering course and have some discretion concerning traditional science content course work, the new state-mandate academic content standards K-12 require the teaching of engineering principles and concepts (Ohio State Board of Education, 2003).

V.C. Population

The population for this exploratory study consists of undergraduate chemical engineering major students who participated in the VITDP. Table 1 shows the distribution of the population based on class rank and gender.

Table 1		
Class Rank		**Population (N = 121)**
Seniors	Total	28 (23.1%)
	Male	19 (15.7%)
	Female	9 (7.44%)

Juniors	Total	27 (22.3%)
	Male	18 (14.9%)
	Female	9 (7.44%)
Sophomores	Total	27 (22.3%)
	Male	21 (17.4%)
	Female	6 (5.00%)
Freshmen	Total	38 (31.4%)
	Male	29 (24.0%)
	Female	9 (7.44%)
Education	Female	1 (0.83%)

Within the chemical engineering program, class rank denotes the different exposure that students have had to fundamental chemical engineering concepts. The population was divided into 13 teams. Each team had two team members of senior rank. The chemical engineering faculty assigned participants to teams. See Qammar, et al. (2003) for a detailed description of the team selection process and criteria.

The population also contains one education major. That student holds an undergraduate degree in biology and is presently working towards state licensure in a master's level program to teach adolescent and young adult learners in the earth and life sciences. Her program requires that she take numerous science courses at the undergraduate level including non-calculus physics, but does not require her to take coursework within the College of Engineering. The VITDP is her first exposure to engineering. Hence she has neophyte or naive knowledge of engineering.

V.D. Sample

The sample for this exploratory study is a group of 26 (21%) VITDP participants. Two participants from each of the 13 VITDP teams were selected for the sample. The sampling was probability nonproportional stratified random sampling (Kemper, Springfield, & Teddlie, 2003). Probability sampling techniques have "the ability to extrapolate findings from a subset of a population…to a larger defined population of people" (p. 277). The population was stratified or grouped into the 13 design teams. Within each design team, the same number of participants was selected randomly. The resultant sample is not proportionally the same as the population in class rank, gender and content major (See Table 2).

Table 2				
Class Rank	**Major**		**Population (N = 121)**	**Sample (N = 26)**
Seniors		Total	28 (23.1%)	4 (15.4%)
		Male	19 (15.7%)	3 (11.5%)
		Female	9 (7.44%)	1 (3.85%)

Juniors		Total	27 (22.3%)	6 (23.1%)
		Male	18 (14.9%)	5 (19.2%)
	Chemical	Female	9 (7.44%)	1 (3.85%)
Sophomores	Engineering	Total	27 (22.3%)	6 (23.1%)
	(Total = 120)	Male	21 (17.4%)	5 (19.2%)
		Female	6 (5.00%)	1 (3.85%)
Freshmen		Total	38 (31.4%)	9 (34.6%)
		Male	29 (24.0%)	6 (23.1%)
		Female	9 (7.44%)	3 (11.5%)
Education	Education (Total =1)	Female	1 (0.83%)	1 (3.85%)

The difference in distribution between the population and sample limits the ability to extrapolate the findings to the population (Kemper, et al., 2003). However, if the sampling technique is random purposeful sampling, "a random sample of units in the purposefully selected target population [then the] sampling adds to trustworthiness, and not generalization, to the findings" (Kemper, et al., 2003, p. 282). Trustworthiness is a statement of credibility, transferability, dependability, and conformability (Lincoln & Guba, 1985). The target population was purposefully selected, as the focus of the design project was to examine specifically engineering students who participated on a vertically integrated design team and an education student. Hence this exploratory study maintains trustworthiness.

Participants within the sample are assigned pseudonyms. The traditional English-speaking cultural names represent the gender of the participant. Students with the same first letter belong to the same design team. For example, Aaron and Annabelle were members of the same team and Aaron is a male student and Annabelle is a female student. Aaron and Clyde are members of different design teams; however they are both male students.

V.E. Instrument

Blake and Blake (2000) constructed the conceptual framework for the affective/associative reflective journals used in this study. Bleich (1975) posited that journals should first encourage untutored, spontaneous feeling responses (affective responses) and then seek to expose the derivation of the feelings (associative responses). The purposes of the reflective journals are to "engage students in the construction of understanding and then creation of personal meaning and to focus on the implications, applications of science to one's life" (Blake & Black, 2000, p. 831), and "to engage … students emotionally and personally" (p. 840). Furthermore, the reflective journals are "to 'create,' not 'find' their own individual, personal meanings" (p. 841) rather than to construct content understanding (p. 843). Reflective journals include the following categories: initial responses (initial, immediate response written upon completion of the [task]), feeling responses (affective), memory responses (relational), and judgmental

responses (application, meaning, and value). In writing the reflective journal, students "pull from previous experiences, link these experience to [the task], and construct their own meaning" (p. 834).

With pre-service teachers reacting to a science-related literature, Blake and Blake (2000) reported the responses were free, immediate, and intuitive. However, the responses were short and lacked evidence and concrete details. "Students uniformly were not tentative in making their inferences, conclusions, and moral judgment about the content clearly and decisively" (p. 841). However, no student "judged the value of the writing itself, a common form of evaluation in literary criticism" (p. 841).

Blake and Blake (2000) posited, "literature is a special way of knowing only if one accepts the fact that it is a special way of knowing, only if the reader lets the piece evoke feelings and trigger deep personal memories and associations" (p. 831). The authors of this paper, as the designers of the assessment protocol, also believe that engineering is synonymous to Blake and Blake's concept of literature; however, engineering students may not perceive engineering as such. Therefore the authors developed an explicitly skilled-based reflective journal. Table 3 shows the connection between the "skilled-based" reflective journal contrived by the authors and the affective/associative reflective journal structure suggested by Blake and Blake (2000).

Table 3.
Reflective Journal Prompts

Affective/ Associative Reflective Journal	Skill-based Reflective Journal
Initial Response: What is your initial and immediate response to the activity or experience in which you were engaged?	**Initial Response**: What is your initial and immediate response to the activity or experience in which you were engaged?
Feeling Response: How do you feel about the activity or experience in which you were engaged?	**Competency Response**: Describe your competency level for approaching the activity you are reflecting on?
Memory Reponses: What experience, young or old, now or then, does the activity or experience reminds you of? What memory helped you understanding your experience or activity?	**Skills for Task Responses**: Where did you get the skills to handle the task?
Judgmental Response: For whom is this activity or experience important? What are important instances or features of the activity or experience? How is the importance of the activity linked to your perceptions, feelings and memories? What did you learn du	**Relevancy Response**: What is the relevance of this activity to the overall goal of the team?

V.F. Data collection and analysis

Each team was required to schedule five weekly team meetings. Twenty-four hours after a team meeting, each team member was to submit individually a reflective journal entry. These reflective journals were electronically sent to the authors. The type of journal, affective/associative or skill-based, was different for each team. The type of reflective journal assigned to a team was changed after the second week. However, not all participants changed the type they were using. Therefore, Table 4 indicates the type of journal the participants wrote. Some participants elected to use an open format. These journals do not include headings as specified in Table 3 and were usually written in paragraph form.

Table 4
Order of Type of Reflective Journal Written by Team

Team	Skill-based Reflective Journal	Affective/Associative Reflective Journal	Free-Form*
1		1, 2, 3, 4, 5	
2	1, 2, ,3, 4, 5		Yes
3	1, 2	3, 4, 5	Yes
4	1, 2	3, 4, 5	Yes
5	1, 2	3, 4, 5	
6	1, 2	3, 4, 5	Yes
7	1, 2	3, 4, 5	Yes
8	1, 2	3, 4, 5	
9	1, 2	3, 4, 5	
10	1, 2	3, 4, 5	
11	1, 2, ,3, 4, 5		
12		1, 2, 3, 4, 5	
13	1, 2	3, 4, 5	

*Reflective Journal did not specify the type of prompts.

The reflective journals were read three ways: (1) the complete collective group that included the affective/associative reflective journals and the skill-based reflective journals; (2) the affective/associative reflective journals collectively (independent of the date in which the journal entry was written) and (3) the skill reflective journals also collectively and independent of the date on which the journal entry was written. During reading and rereading of the reflective journals, the authors searched for specific themes, patterns and

categories as suggested by the conceptual framework. In other words what are statements from the reflective journals that would generate a general description of teamwork (Creswell, 1998). The reflective journals were read and reread until themes, patterns and categories emerged to indicate the content of a phenomenological narrative (Kvale, 1983). Also, through the readings and rereading other themes, patterns and categories that were not predetermined were identified (Heath, 1982).

VI. Findings

VI.A. Phenomenological Statements

The analysis of the reflective journals was phenomenological. Hence the findings of this exploratory study are best reported in terms of statements (Creswell, 1998). These statements best represent the experiences of the participants. The following phenomenological statements of findings represent themes, patterns and categories that emerge from the reading and rereading of reflective journals:

Combined Affective/Associative Reflective Journals and Skill Reflective Journal

- Statement 1. The VITDP is too large for one person to complete within the time frame.
- Statement 2. Everyone needs to be equally knowledgeable about the solution. Seniors could do everything.
- Statement 3. Group (team) work demands trust to do assigned task (doing your task).
- Statement 4. Knowledge that individual team members possess is pre-determined.
- Statement 4a. Team (or seniors) perceives (or know) what any team member can do based on class rank.

Skill Reflective Journal

- Statement 1. However, I might question my competency with the skill, but I am confident that I will complete the task.
- Statement 2. The assigned task is relevant to completing the project.

Affective/Associative Reflective Journals

- Statement 1. Learning occurs in a social environment.
- Statement 2: I engaged in thinking about my thinking (metacognition).

VI.B. Definition of Teamwork

In addition to the phenomenological statements gleaned from the reflective journals, a few participants in the sample offer a definition of teamwork. For example, Bill, a junior, used team sports as a simile:

> (Skill Response) as for the ability to work well in a team setting, that was something that was learned over time from a combination of school projects and team sports. (journal 2)

Doug, a senior, gave a clear definition of a team. He stated in his journal:

> (Competence Response) The project is over too short of a period of time to really teach those that don't understand the process… (Judgmental Response) … this is not how the team should work. Everyone should have an equal hand. (journal 1)

In his first skill reflective journal entry, Fred, a freshman who was "a carpenter for twenty years," stated:

> (Judgmental Response) We meet as a team. There are people in charge; we all have tasks to complete to create the 'big picture' and we are all held responsible because each member relies on the other. (journal 1)

These definitions are not extensive, however, students were reflecting on the content focus of the VITDP rather than directly address the question: What is the definition of a team or teamwork?

VI.C. Metacognition

Also some students engaged in thinking about their thinking – metacognition. Annabelle's reflective journal indicates selection and control of her cognitive strategies as.

> (Feeling Response) I felt determined to understand the patent and provide something for our team. I shut out my worries about looking stupid and motivated myself to take down some notes and then create a summary. (Annabelle, freshman, journal 2)

Bailey focused on the execution of cognitive strategies in order to work on the design problem.

> (Memory Response) At first it is a whole new world, but after practice, it becomes like the cliché of riding a bicycle (once you know how, you never forget…. (Judgment Response … I re-learned the fact that patience and persistence will pay off. (Bailey, senior, journal 4)

As outlined by Flavell (1987), Fred used his understanding of the task to select, execute, monitor, and control the use of cognitive strategies .

> It reminded me of the many (literally hundreds) of times that I have been given a task to perform (I was a carpenter for twenty years) and how I felt

> overwhelmed at the immensity of the project and…. I did know what I always did back then. First, suppress the urge to panic by not looking at the whole but focusing on one part. It becomes a lot less intimidating in smaller parts. Second, ask for clarification so you can focus on the first small part that needs done in the process. This will lead to a lot less stress and a lot more productivity. (Fred, freshman, journal 1)

VII. Discussion

VII.A. Reflective Journals as an Assessment Tool

Since knowledge conceptually exists in the head of the learner and new knowledge and understanding are constructed on the basis of what the learner knows, reflective journal writing engages the learner in communicating attitudes, feelings, and judgments that reside within the head of the learner. As well, through reflective journal writing, the VITDP participants expose experiences, knowledge, and skills that the learner activated and used for problem solving. Thus, reflective journals are meaningful as assessment tools because they are a means of understanding how VITDP participants learn. As well, if assessment is to guide decision making concerning what needs to be emphasized and what is essential (Wiggins & McTighe, 2001) the reflective journals are important to the curricular and instructional designers of VITDP.

If the purpose of the journals is to be an instructional tool in addition to an assessment tool, then the affective/associative reflective journals are stronger than skill-based reflective journals. Although the analysis of the reflective journals did not include a count of specific predetermined and defined responses, the findings show that affective/associative reflective journals have the ability to focus on metacognition. The phenomenological statements for the affective/associative journals indicate "a metacognitive approach to learning ... that focus[es] on sense-making, self-assessment, and reflection on what worked and what needs improving. These practices have been shown to increase the degree to which students transfer their learning to new setting and events" (NRC, 2000, p. 12). Also, whereas skill based reflective journals focus on reporting facts and skills, the affective/associative journals support understanding in addition by providing a personal dimension to ideas and events; means to see and hear points of view through critical eyes; and knowledge about personal style, prejudices projections and habits of minds that both shape and impede out own understanding (Wiggins & McTighe, 2001, p. 44).

Furthermore the affective/associative reflective journals, during this exploratory study, yield rich and thick descriptions of prior knowledge and understanding. These journals need to be read and reread. In reading the reflective journals, the reader needs to focus on what participants are thinking and how participants make sense of what they are doing but more importantly, the reader needs to examine why the participant values and uses the "whats" and the "hows" (Broadway, 1999). From these insights into the sense-making process of the participants, the authors of this paper can make curricular and instructional

decisions.

VII.B. Concept of teamwork

Teamwork, based on an analysis of the reflective journals inclusive of the format, was often expressed as a means of increasing efficiency. For these engineering students, the process of teamwork included splitting the task into smaller pieces and pulling the task back together. All team members make the decision about accepting the work of individuals or groups, on the next direction for individuals or groups if refinement was necessary and on the content and evidence to include in the final project.

Although many students commented on the lack of content knowledge and skill to address the engineering problem individually, the participants applied what they did know to the problem. Some students commented on learning content and skills for the first time from members of the team with senior rank. However, the identification of the strengths of each team member was *a priori*. In other words, although responsibility for tasks was not assigned arbitrarily, class ranking often determined the ability of each team member rather than knowledge of the individual. Thus, there was very little identification of and capitalization on the strengths of many individual team members. Therefore, synergy was not a characteristic of the teamwork during this VITDP.

There is evidence that participants feel that the members with senior academic rank, at best, could complete the calculations if they had the time and could make decisions concerning the project individually and without the help of other team members. However, there were seniors who facilitated learning and participating of underclassmen. Seniors engaged underclassmen in reviewing the work of team members and instructed underclassmen in the use of engineering tools. Also, seniors explained problem areas to other members of the team. There were strong statements that the most relevant learning took place during interactions with seniors. However, there were no journals that discussed the learning of engineering content and skills by the seniors.

In reference to Vygotsky's (1978) zone of proximal development, Tudge & Rogoff (1989) stated "children learn to use the tools and skills they practice with their social partners" (p. 25). For freshman, many tasks were completed using the knowledge gained through experience prior to the VITDP. Sophomores and juniors built upon their learning during earlier VITDP experiences. Thus for the underclassman, the learning of content, skills and attitudes was through social interaction.

Therefore, the conceptual description of teamwork lacks both consensus and synergy. Although the team made decisions, the seniors hold most of the cultural capital within the team. Cultural capital is the amount of knowledge concerning engineering content and skills. If underclassman were to gain cultural capital, they needed to assert themselves and some were assertive. Thus, there were elements of consensus with teams that have interaction between a team member and a more competent team member. Many team members worked through difficult concepts and explained problem areas to one another.

In those cases, not only did underclassmen learn through social interactions and have a unique perspective (Confrey, 1995; Tudge, 1990), albeit based on the meaning of another team member, decision-making was from many perspectives. Hence, these teams engaged in elements of teamwork (Cohen, 1994).

Teamwork for the participants in this exploratory study of VITDP is solving an engineering design problem that is too large for one person to complete within a given time frame. With elements of trust, team members must complete relevant tasks in order that at team meetings all team members are equally knowledgeable about the solution. From this knowledge base, the team makes decisions. Also, in building the knowledge base, team members need to interact. Teamwork is a social environment in which to learn engineering content and skills.

VII.C. Metacognition in the reflective journal

Those journals that connote metacognition were strong on the affective and skill dimension of the reflective journals. Participants often expressed self-knowledge; however, self-knowledge was limited to behaviors rather than self-knowledge of cognitive strategies. Specifically, participants described how they would "work harder." Participants communicated the skills that were acquired such as the use of Visio and Chemcad, the creation of PFD's, and information research, especially for patents and Internet resources. However, there were few moments of association. Participants did not explore "possible events in their lives that may have prompted [the] affective responses" (Newton, 1991, p.477) nor select, execute, monitor, and control of the use of cognitive strategies, characteristics of metacognition (Flavell, 1987; NRC 2000). Participants did not report the use of cognitive strategies such as sense-making and self-assessment.

During this exploratory study, the reflective journals themselves do not facilitate the construction of knowledge, but do record the activities and processes, which socially constructs knowledge. The journals are a record of activities and thoughts of the writer. The authors of the reflective journals chronicled tasks and activities that lead to learning. Hence, the majority of reflective journals are statements of involvement or work logs.

VIII. Conclusions

Bryan and Abell (1999) wonder, "How do we help [teacher candidates] to articulate, analyze, and refine their beliefs about teaching and learning?" (p.172). In teacher education, reflection and metacognition are a means of helping teacher candidates articulate, analyze and refine their beliefs about teaching and learning. Reflection and metacognition are taught and practiced by teacher candidates throughout the teacher education curriculum. Therefore, teacher education has produced a body of literature that emphasizes the importance of reflection and metacognition in creating effective teachers.

Likewise the authors of this study posit that reflection and metacognition would strengthen the ability of engineering students to articulate, analyze and refine their beliefs about and practice of engineering in general and engineering design and teamwork in particular. This exploratory study shows that like in teacher education these reflection and metacognition activities need to be taught not in a single environment such as the VITDP, but throughout the curriculum. Summative evaluation of this pilot VITDP indicates that the reflective journals were meaningless for many participants (Qammar, et al., 2003). However, in this paper, the authors through use of reflective journals have garnered much information concerning the cognitive structure participants brought to the VITDP, the learning of participants about teamwork, and instructional design. Hence, the reflective journals are meaningful assessment tools.

The reflective journals indicate areas that need attention in order for teamwork to be better understood by engineering students and the VITDP to be a stronger curricular and instructional tool. For example, the methods for the development of synergy are an instructional design concern. How can communication plans be developed to identify the strengths of each team member and then capitalize on those strengths? How can teams determine who has the required skills to handle different responsibilities and delegate accordingly? How can consensus be reached on how the tasks are handled with input from different perspectives? Qammar, et al. (2003) report that team members do not know all individual members of the team well. Another curricular and instructional concern is the seemingly implicit role of seniors. The role of seniors and other upperclassmen that have participated in past VITDPs must be made explicit so that the use of the vertical integration component of the VITDP is strengthened and *all* team members learn.

In order to increase the potential for reflective journals to assess metacognition, VITDP participants must see the value of reflection and metacognition as a learning tool. In terms of reflection, participants need to be taught that reflection is a meaning making process. Reflection is a means to activate the prior knowledge and experience upon which present experience will become meaningful (Confrey, 1995). Participants need to be taught: (1) what are cognition strategies, (2) what is metacognition, (3) the role of metacognition in learning, and (4) how to use reflective journals as a metacognition tool. With more instruction in reflection and metacognition participants can construct more complex, related, and integrated knowledge structures with which to learn (McCrindle & Christensen, 1995).

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