Enhancing Design Education by Processing the Design Experience

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Abstract

Experiential learning can be simply described as learning through doing. It is a process through which individuals construct knowledge, acquire skills and enhance values from direct experience. Traditional engineering education has included experiential components through laboratory assignments often linked with a course. Students would read the lab handout, perform the procedures, and then write a brief lab report describing the results which is then graded and returned. Principles of experiential learning suggest a more active approach that is better suited to design education. Throughout the experiential learning process, learners are actively engaged in posing questions, investigating, experimenting, being curious, solving problems, assuming responsibility, being creative and constructing meaning. A design report tends to focus on the final designed artifact and its satisfaction of the design specifications. It does not often reflect the learning from the experience of designing. Meaningful learning occurs through reflection and resolution of cognitive conflict. This paper describes techniques for processing the design experience; that is, guiding the students through meaningful reflection. The result is that students gain more than just the experience of completing a design, but an enrichment and realization of the methods and skills developed.

I. Introduction

Many engineers contend that design is the heart of engineering. Traditional engineering curricula were based on the concept that a strong foundation in engineering sciences would naturally lead to better designers. The curriculum would often contain some form of a capstone design experience where students would be given a design problem to resolve. The students may or may not have been taught how to best approach the solution to the design problem. At the end of the allotted time period (a semester or some other number of weeks), the design project would culminate with the delivery of a design report and, perhaps, a presentation. The students' performance was then evaluated on some quality measure of the final design product and accompanying documentation. Perhaps this practice stemmed from the traditional laboratory course process where the students read the lab handout, perform the experiment, and write a lab report on the results.

It has only been in the last decade that design methods have been accepted and widely taught, as evidenced by the abundance of design texts published in the 1990's. While design methodologies vary with the authors, the general flow remains consistent: define the problem, establish engineering requirements, generate concepts, design details, evaluate, and present the results. As the students make progress on their project, there may be some discussion and feedback from the faculty. This often occurs in written and oral form. However, the content of the discussion is often focused on the project results. The expectation is that the students will be able to generalize from their design experience to other design projects.

The premise of this paper is that meaningful learning occurs through reflection on the design experience. It cannot be assumed that the reflection occurs automatically. Instructors can ensure that the students are reflecting by engaging them directly in the process. The techniques for managing the reflection activities are often referred to as *processing* in experiential learning circles. "Processing teases out the richness of the experience so it stands out and apart, like the important lines of a page underlined with a yellow highlighter" [1].

The paper will begin with a brief review of experiential learning theory. It will then describe how these theories apply to the design experience. This will be followed with direct techniques and common questions useful for processing the design experience.

II. Experiential Learning

Support for experiential learning is found in the work of Dale[2] who suggests that people learn and retain: 20 % of what they hear, 30% of what they see, 50% of what they see and hear, 70% of what they discuss, 90% of what they experience directly or practice doing. These figures suggest that there is a definite educational benefit to engaging students in experiential activities such as designing a real-world product. However, as Joplin[3] recognizes in "On Defining Experiential Education", engaging students in "different actions has often become confused or synonymous with experiential education." "Experience alone is insufficient to be called experiential education, and it is the reflection process which turns experience into experiential education."

The benchmark work for establishing an experiential learning model was described by Kolb[4] where immediate concrete experience is the basis for observation and reflection. The Kolb cycle shown in Figure 1 begins with a concrete experience. Deeper learning occurs from students making observations and reflections on that experience, then abstracting what is learned to form generalizations. This is followed by testing the implications of the concepts in new situations. Ultimately, the learned information is fed into new concrete experiences and refined through successive operations through the cycle. The tenet of this learner-centered model is that teachers must go beyond merely providing the opportunity for concrete experience. Teachers must also guide students through the cycle by processing the experience.

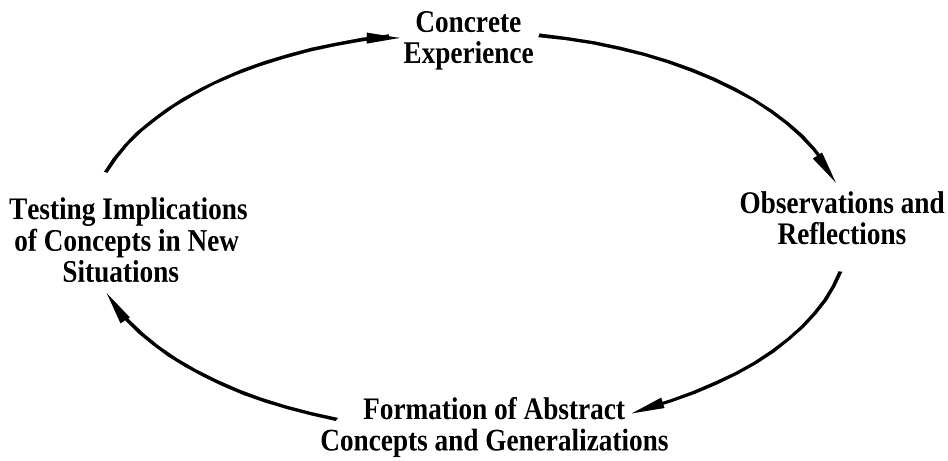

Figure 1: Kolb's Experiencial Learning Model

Cowan[5] expands upon the Kolb model He suggests that the Kolb model focuses on reflection **of** action that is repeated through the experiential cycles. Cowan's model shown in Figure 2 includes an element of refection **for** action and **in** action, as well as **on** action. He illustrates the process as a sequence of advancing Kolbian coils that include the consideration of formulating further actions based on what is learned. Cowan's book is of particular interest because of his background as a professor of engineering education. While he has several interdisciplinary examples, he includes an engineering focus.

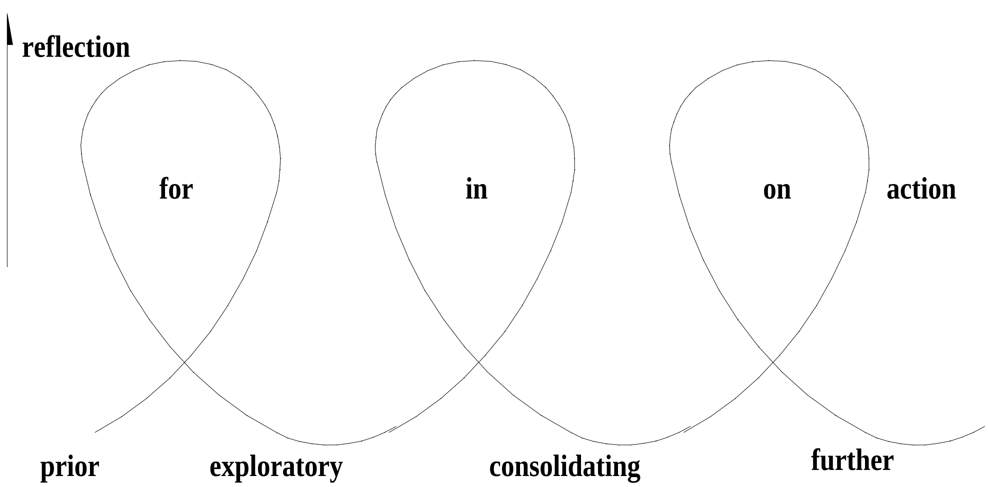

Figure 2: The Cowan Diagram

Wankat and Oreovicz[6] suggest a six [seven] step strategy for problem solving: Motivate, Define, Explore, Plan, Do it, Check, and Generalize. Of particular interest to this paper on experiential learning are the first and last steps. As Wankat and Oreowicz recognize, "since anxiety can be a major detriment to problem solving, it is useful to work on the student's self-confidence." The design experience is fraught with the unknown because it often involves the creation of something new. Even the instructor does not know the answer ahead of time. Throughout the design process, students will naturally encounter a broad range of feelings: anxiety, frustration, excitement, among others. As a natural part of the design experience these feelings should be acknowledged and discussed.

Wankat also recognizes that "the last step, generalize, is almost never done by novices unless they are explicitly told to do it. What has been learned from the content? How could the problem be solved much more efficiently in the future?" Perhaps one failing of Wankat's excellent text is that he stops at this statement of "telling" students to generalize. Because students are understandably novices, it cannot be assumed that they understand how to generalize. Educators cannot suppose that adequate reflection has occurred unless they engage the students in the process.

Kolb and Lewis[7] describe the environment for experiential learning and the role of the teacher. "A behaviorally oriented environment is characterized by activities designed to have the learner apply knowledge and skills to solve real-life problems as a professional would. Information sharing is centered on what is necessary to plan, schedule, write, prepare presentations, and so on in order to finish a task; learner autonomy or minimal rules or guides forces learners to take responsibility for their action; teachers serves as coaches who guide by offering friendly advice based on personal experience but leave responsibility for the outcome to the learner; and learners are left to judge their own performance by using professional criteria they accept as valid."

A significant arena for experiential learning techniques has been in adventure programs such as Outward Bound, and many publications target that audience. In **Processing the Adventure Experience**, Nadler and Luckner[8] describe a series of useful techniques for facilitating experiential learning. They acknowledge that "planning time for processing and appropriately structuring those sessions provides the greatest opportunity for the experience to have long-term personal effects. To be a successful facilitator of processing the experience, you will want to be able to integrate theoretical constructs of adventure-based learning with specific group process skills and techniques in order to enhance and cement the learning of students."

There are many similarities between adventure experiences and the design experience. Both involve the encounter of a series of open-ended problems that require resolution. The choices made in the solution to one problem often influences the possibilities and approaches for the next problem. Two groups assigned the same task can experience very different challenges based on their own choices. There is also the nature of collaboration and teamwork. The problems are often of significant complexity that all individuals in the group must contribute to attain adequate resolution. The nature of the teams requires the group to effectively manage the individual skills. There is also the need to adequately manage finite resources in the attainment of the goal. In both cases, the experience is so rich in activity that often the focus remains on the solution to the problems at hand. However, the true opportunity for learning stems from gaining insight into how they arrived at the solution. Processing the experience provides an opportunity for deeper learning and greater retention.

III. The Design Experience

There are many ways that design is incorporated in the engineering curriculum. There are often opportunities for short design exercises within discipline-focused courses. These are often by necessity limited in scope and complexity to address an issue germane to the current material. Processing these experiences is still valuable. In fact, it is in these instances that processing most likely already occurs in some form because the instructor has invested significant effort in the problem to highlight a particular point.

Most curricula include some form of a capstone design experience in which the students work in teams to design a solution to a fairly complex problem. The design process requires the incorporation of knowledge from a multitude of previous courses. Often, students must develop new knowledge in fields that they have not previously studied. The design projects are established as long-term exercises often lasting the entire semester or even longer. The design effort is expected to proceed through some taught design methodology. Often, however, groups work on different design problems so that at any given time there is the need for knowledge in at least as many different domains as projects. They make decisions, resolve conflict, and, through iteration, progress forward towards a solution. They cannot easily compare their own solutions to other groups because the other groups are not working on the same problem. They are forced to determine the viability of their actions for themselves and develop techniques for establishing confidence in their decisions. Through the chaos, students struggle to construct meaning.

The design experience is filled with a myriad of trials and tribulations, successes and failures. Designers are often forced to iterate and reconsider past decisions. As students progress through the design process, they are in a continuous state of disequilibrium. However, this provides the greatest opportunity for change and growth. Disequilibrium in itself is not necessarily a negative state. In fact, some organizational theorists suggest that disequilibrium might be a better strategy for survival in the corporate world than coherence and order[9]. The key is to help students manage, cope, and thrive in this state of disequilibrium.

Figure 3 depicts the state of disequilibrium as described by Nadler and Luckner[10]. In general, people prefer to act in their comfort zone where everything is known and understood. Creative design requires the exploration of new territory. Breaking through to the realm of new possibilities involves confrontation at the edge of the known and unknown, comfort and discomfort. It is often in the realm of new territory that success is achieved, but new learning occurs primarily at the edge, which is also the highest state of disequilibrium. Typically, processing occurs after the activity or success, which is labeled S+1. This is very valuable. However, greater insight can be gained by examining the actions at the edge right before success at S-1. What happened to allow for a successful leap, or what caused retreat to safer territory? It is at the edge at S-1 where the profound insights can be found for use again in other design settings.

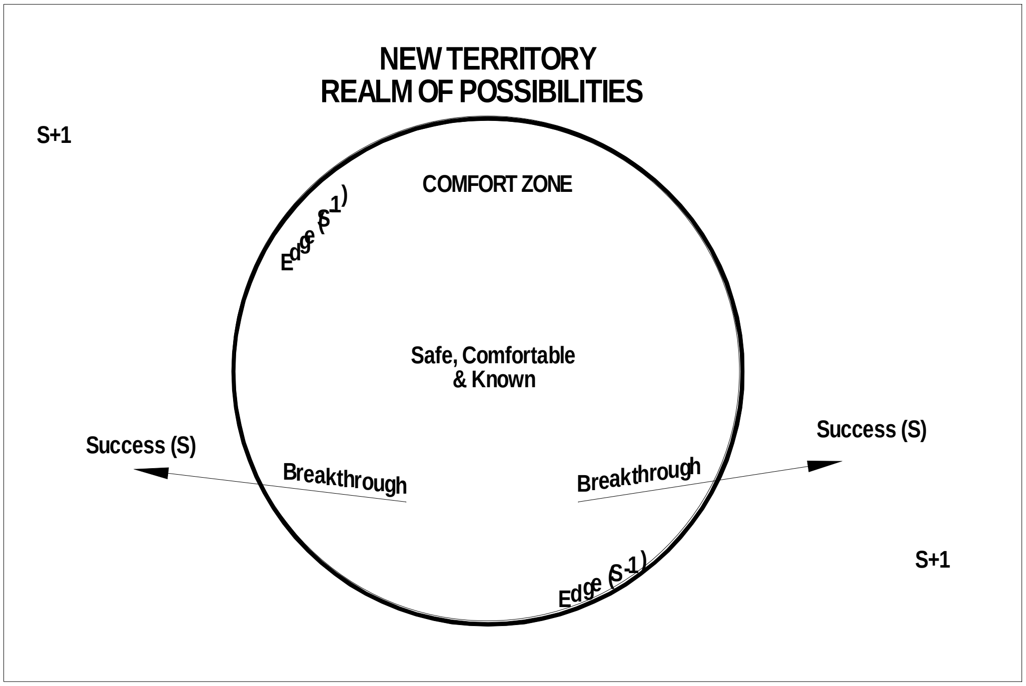

Figure 3: Breaking Through to New Territory

An examination of the design experience suggests that there are two types of processing that would prove beneficial. The first involves processing on the project itself. Included in this are discussion of techniques and tools used to develop the new technology. The second involves processing the experience. This includes reflection on the actions as well as the feelings associated with the experience.

IV. Levels of Processing

The purpose of processing is to assist students through meaningful reflection. The overall intent is to: a) provide opportunities for new perceptions, new directions, and new options for students; b) have students become interested in their own patterns of development and interaction; c) form connections and links to other experiences; and, d) have students experiment with new behaviors and techniques.

Processing provides the most profound impact when it occurs at progressive levels. The first level focuses on developing awareness. It is important to bring forward an awareness of the actions, thoughts, skills and techniques that have occurred. Through awareness students can identify behaviors that have been successful and why. In the design process, students will perform a wide range of activities. Some useful questions for engaging students in developing greater awareness include:

What was your intention in this activity?
What were the roles of each of the individuals in the activity?

What skills or knowledge was required to perform this activity?
How was this activity different than another?
What resources were best applied to the activity?
How did you function as a group?

The second level of processing is responsibility. Students recognize and take responsibility for their behaviors and how they affect the progress of the project. Some useful questions include:

What strengths did you bring to this activity?
Did you achieve the level of your expectations?
What challenges were encountered?
How were resources used?

The third level of processing involves experimentation. The objective is to give students the opportunity to create new options and choices. Some common questions include:

What alternative approaches did you explore?
What was the level of risk in your choices?
When did you first notice that your approach would be successful?
How much influence do you feel you have over the approach pattern?

The fourth level of processing involves generalization and transfer. The objective is to maximize what has been recently learned so that it can be used in another design experience. Some useful questions include:

How might a similar situation be approached for greater success?
What were some of the strengths that led to the result?
What were some of the weaknesses that let to the result?
Develop a toolbox and explain what is in it to help you attain your goals on the next design.
What will be the first signs on the next activity to let you know that you are on the right track?

V. Processing Particular Behaviors

In addition to considering the levels of processing, it is often beneficial to focus attention on particular behaviors. Because the design experience is complex, it is not possible to consider every aspect during one session. It is often helpful to do focus sessions on one particular aspect of the design experience. Some topics for consideration include communication, making group decisions, cooperating and teamwork, problem-solving, leadership and following roles, giving and receiving feedback, and trust and support. Some useful questions in several of these categories are described in Nadler and Luckner[11]. Below are some suggestions:

<u>Communication</u>:
What were some of the effective forms of communication used? Ineffective?
In what ways could the group's process of communication be improved to enhance problem-solving skills?

Making Group Decisions:
How did the group make decisions for completing the task?
Were decisions made by one or several individuals?
Did everyone express his/her opinion when a choice was available?

Cooperating and Teamwork:
What are some specific examples of when the group cooperated during the activity?
How did cooperative behavior lead to the successful completion of the tasks?
How did you develop your plan of action?
What is the relationship between input into the plan and commitment to action?

Problem Solving:
Have you noticed any patterns in the way you solve problems?
What would need to change in order to enhance you problem-solving ability?

Leadership and Following Roles:
Who assumed leadership/follower roles during the activity?
What behaviors would you describe as demonstrating leadership/following?
What type of leader was easiest to follow?
What specific skills are needed to be an effective leader/follower?

Giving and Receiving Feedback:
What are some examples of when you gave/received feedback?
How was appreciation expressed for success?
How was failure expressed?

Trust and Support:
What impact does trust have on the relationships within the group?
What is the relationship between managing risk and establishing a support system?

VI. Methods of Processing

For ideal processing, the instructor would be continuously engaged in the design activities to monitor opportunities for processing. However, this is not possible or practical in long-term projects for obvious reasons. As described earlier, an opportunity for learning is lost if processing occurs only at the end of the design project. It is therefore most practical and useful to have regular, periodic sessions established. This does not mean that impromptu opportunities should not be exploited.

Processing activities can be established for group sizes that include the entire class, design groups, and individuals. Much of the focus will naturally be placed on the design groups. It is more effective to have regular, brief sessions (about 30 minutes) rather than longer sessions less often. The sessions can be established for progression through the levels of processing or focus on particular behaviors. Some of the questions from the previous section are helpful for starting the discussion. However, one should not be afraid to let the discussion progress on its own. It is important to include every individual in the discussions.

Processing is also helpful at the individual level. Some students are reluctant to openly discuss some of their concerns. A journal is a powerful tool for exploring personal and emotional knowledge. Writing makes possible extended and involved thought. It encourages reflection and explicitness, often leading to a renewed awareness of an individual's knowledge. Encouraging the use of a journal supports students establishing patterns of self-reflection. It is often helpful to prompt students to write in their journal by asking them to focus on a particular question or concern. Because trust is important, journals are maintained for the benefit of the student. They should not be collected or read to the group, although individuals may be encouraged to share their thoughts.

It is also beneficial to do large group processing activities with the entire class. One activity that has proven particularly useful is to have a design group lead the discussion with the class. The design group briefly presents a single aspect of their design that they worked on. The students are encouraged to focus on the techniques and behaviors demonstrated in that design activity rather than the technology or the result. These group discussions provide an opportunity to gain insight into the problems faced by other groups, and formulate generalizations to applicable situations on their project.

VII. Feelings

The design experience illicits a wide variety of emotions ranging from anxiety, frustration, anger, excitement, contentment and joy. Students need to realize that these feelings are a normal aspect of the experience. Generally, people don't know what to do with their feelings. Because they can be painful, uncomfortable and embarrassing, it is often easiest to just ignore them. However, ignoring feelings does not reduce their power. Feelings are a natural part of being human. The intense nature of the design experience provides an opportunity to help students acknowledge their feelings and approach them in a positive, healthful manner.

Working through feelings involves a three-step process. The first involves identifying and acknowledging feelings. While feelings may be clearly exhibited as bursts of anger or exclamations of joy, they are often more hidden and subdued. They can be exhibited in other external behaviors such as bossiness or shyness. They can also be found in psychosomatic symptoms such as headaches or an upset stomach. It is often helpful to spur students' acknowledgement by simply asking them what they are feeling now, or how they felt during a particular activity. The second step involves honoring and accepting feelings. To feel is natural. Avoiding feelings is unnatural and can lead to deeper problems.

The third step for working through feelings occurs when the individuals deliver, experience or communicate feelings to self or others. It is important to work on expressing feelings in a responsible manner rather than through defensiveness or blaming. The journal provides a safe haven for the expression of feelings. Students should be encouraged to work through their feelings and establish productive techniques for managing them. As experienced educators of design recognize, it is not a question of "If" an emotional blowout will occur but "When". Although it may make us uncomfortable as educators to acknowledge feelings, we know that we will ultimately deal with the fall-out from ignoring them. During processing, the instructor can ask if students would like to share some of their feelings with the group. Students should not be forced to share their feelings. When emotions are directed toward individuals, the opportunity should be taken to discuss how the feelings can be more constructively expressed.

VIII. Conclusion

Processing is a valuable tool for enriching learning from the design experience. Processing helps students to discover and recognize what they already know from the experience. It helps them to assimilate knowledge into a more fluid process from a state of fractured knowledge. Through reflection, they can generalize to form better approaches for future designs. Active processing of the design experience also helps students to recognize early successes to build confidence for more complicated tasks. The result is that students gain more than just the experience of completing a design, but an enrichment and realization of the methods and skills developed.

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