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# COLLABORATION IN THE ZONE OF PROXIMAL DEVELOPMENT

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**ABSTRACT**
The zone of proximal development (ZPD) is defined as the space between what a learner can do without help and where the learner needs significant instruction. The ZPD is at the edge of where a learner can succeed only with mentor guidance, or in collaboration with more capable peers—in other words someone who has a broader knowledge, experience, or skill set. This kind of support has been termed *scaffolding*. Scaffolding suggests a temporary and flexible support that can be quickly and easily assembled and disassembled once the learning task is accomplished. The learner's ZPD development is expanded and scaffolding is moved to the edge of the new learning frontier. Giving learners the most rigorous tasks they can do with minimal scaffolding leads to the greatest learning gains.

This paper discusses the ZPD in terms of a collaborative design project where collaborative mentors use a student-created artefact to pull a learner to a series of "need to know" places--places that indicate the edge of the learner's independent ability. The successful completion of the artefact requires the learner to connect with a number of collaborators, courses, and disciplines, each with specific knowledge, experience, tools, and/or skillsets. These collaborative mentors combine to provide the scaffolding the learners need to complete the artefact in a efficient and uninterrupted path. We further discuss the advantages of extending this "need to know" impetus across course boundaries in a collaborative teaching environment and the struggles of implementing a more complex collaborative design project.

*Keywords: Instructional Scaffolding, Zone of Proximal Development, Collaborative Design Project.*

## 1 INTRODUCTION

The skills, tools, and knowledge required to educate industrial design students are expanding and changing [1]. Design research methods, new materials and processes, rapid prototyping technologies, digital creation and presentation skills, user experience and interface, design thinking, and innovation are all aspects of a designer's education that are becoming more important. Examining how to incorporate these new and changing competencies while still retaining important core design skills is important to the education and training of a professional industrial designer.

Teaching a broader base of knowledge, skills, and tools and pushing a student learning with limited resources—faculty, facilities, finances, and credit hours—is a complicated task. Such a task requires new, efficient and useful ways to approach educating designers within these academic constraints. Frank Lloyd Wright said, "Man built most nobly when limitations were the greatest" [2] in other words sometimes constraints lead to more elegant solutions. We must learn how to engage and motivate students to help them take ownership of their own education.

## 2 PROJECT-BASED LEARNING

Project-based learning is receiving a lot of attention in the academic media. These learn-by-doing methodologies are becoming popular in both K-12 and university environments. This approach based on the desire to move away from a traditional lecture-based pedagogy toward an experiential, more involved pedagogy. In this project-based model, students work together to learn, and activities are structured to emphasize collaborative, active, student-based discovery. Faculty serve as mentors by providing projects, observing learning, answering questions, providing opportunities, listening, and watching more than lecturing [3].

Project-based instruction has been a focal point of most design education for over a century [4]. It was adapted from the early training of artisans, where education was to support and build real-world skills [5]. Today, most models in design education trace their roots to the approaches developed in the Bauhaus school, under the direction of Walter Gropius and Johannes Itten, who promoted learning to design by actually working on designs [4]. The Industrial Design program at BYU has been employing this project-based method of teaching for more than 40 years with good success. Project-based learning requires more involvement from the students and a different involvement from professors.

The involvement from the students is a less independent and much more collaborative learning experience. All the students' work is made public to allow peers and professors to see and participate in the learning process. Work is viewed and discussed by peers, professors, and outside experts who give the students feedback. Students learn to accept feedback as a powerful tool to define and refine their ideas. These project-based learning environments are highly collaborative and less formal, which helps students feel more comfortable with sharing their ideas.

The professors role changes as they act as a guide or mentor to the students, with a focus on student thinking, discovery, and application rather than simply on disseminating information. The professor provides projects that will teach what the desired learning outcome is for the course. This means that professors have more contact hours with the students as they work to guide the student in their thinking and learning.

How can we leverage project-based learning by doing it more effectively? This paper focuses on experimental approaches being used by industrial design instructors at Brigham Young University that build on project-based pedagogy by helping student motivation, collaboration, and mentoring.

## 3 MOTIVATION

Experts suggest that people learn more effectively and are more creative when they are intrinsically motivated. Productivity can be increased by using extrinsic rewards such as grades when the tasks are routine, but the quality of higher-level learning is influenced most by intrinsic factors. If they are doing something that you find rewarding, interesting, and challenging, you are more likely to experience a more lasting and deeper learning [6].

Malone and Lepper [7] define activities as intrinsically motivating if "people engage in it for its own sake, rather than in order to receive some external reward or avoid some external punishment. We use the words *fun, interesting, captivating, enjoyable, and intrinsically motivating* all more or less interchangeably to describe such activities."

Malone and Lepper suggest several different ways to make learning environments that are intrinsically rewarding. The factors that they identify as increasing intrinsic motivation are:

- Challenge: People are more motivated when they pursue goals that have personal meaning, that relate to their self-esteem, when performance feedback is available, and when attaining the goal is possible but not necessarily clear, certain, or easy.
- Curiosity: Internal motivation is increased when something in the physical environment grabs the individual's attention and when something about the activity stimulates the person to want to learn more.
- Control: People want control over themselves and their environments and want to determine what they pursue.
- Cooperation and Competition [collaboration]: Intrinsic motivation can be increased in situations where people gain satisfaction from helping others and also in cases where they are able to compare their own performance favourably to that of others.
- Recognition: People enjoy having their accomplishment recognized by others, which can increase internal motivation.

Using a few of these motivators helps to develop a pedagogy that challenges, push collaboration and provides enough autonomy to engage students more efficiently and effectively in the learning process.

## 4 COLLABORATION AND THE ZONE OF PROXIMAL DEVELOPMENT

When students are motivated to expend effort to explore difficult problems or make sense of challenging ideas, they engage in a struggle that goes beyond passive learning to build useful, lasting understanding and skill [8]. The point at which this struggle becomes acute has been termed the "zone of proximal development."

The zone of proximal development (ZPD) is defined as the space between what a learner can do without help and where the learner needs support. The ZPD is at the edge of where a learner can succeed only with guidance from a mentor or in collaboration with more capable peers—in other words someone who has a broader knowledge and skill set [9].

Each member of a collaborative group would have a different level of ability, and so would have a different ZPD within the context of a project. This allows peers to help members who have skills and knowledge that are different from their own, and thus provide the support necessary in a collaborative effort for the group to work together toward the same goal. Vygotsky views interaction with peers as an effective way of developing and extending learning.

Summers [10], former president of Harvard University, said, "Collaboration is a much greater part of what workers do, what businesses do and what governments do. Yet the great preponderance of work a student does is done alone at every level in the educational system. Indeed, excessive collaboration with others goes by the name of cheating."

Collaboration is a way to leverage others to help provide the broader education students need. Collaboration between students, professors, courses, and disciplines is one tactic to make learning experiences more comprehensive or impactful. As projects become more complex, students need a broader base of knowledge and skills to draw from, and collaboration is a way to fill these gaps.

The mentor, either professor or peer, must work closely enough with the learner to be available when the learner reaches the "need to know" point to provide a 'boost' that enables [or supports] further learning This boost is called scaffolding.

## 5 SCAFFOLDING

This mentored support has been termed *scaffolding*. It is important to note that the terms *cooperative learning, scaffolding,* and *guided learning* all have the same meaning within the literature. Scaffolding suggests a temporary and flexible system that can be quickly and easily assembled and disassembled once the learning task is accomplished, at which point the learner's ZPD is expanded and scaffolding is moved to the new edge of the learning frontier. Giving learners the most rigorous tasks they can do with minimal amount of scaffolding leads to the greatest learning gains. Scaffolding (i.e., assistance) is most effective when the support is matched to the needs of the learner. This puts them in a position to achieve success in an activity that they would not have been able to do alone. This also gives students more control over their learning.

The professor's role is to leverage peers as scaffolding by knowing who and where peers can help in a project in order to facilitate the students' learning activity as they share knowledge and skills through collaborative interaction [11]. Some tasks will be beyond the peers' ability to provide scaffolding, so the professor may step in to provide the scaffolding. Some tasks may even be beyond the professor's knowledge and skill set, so the professor must find a mentor who can provide the help needed. Vygotsky held that when a student is in the ZPD for a particular task, providing the appropriate assistance would give the student enough support to achieve the task.

This "boost" is a key feature of effective scaffolding. The mentor should be careful not to alleviate the struggle or take control, but to help support the learner in their struggle. This support can include general encouragement, modelling a skill, or providing hints or cues [12], or, when needed, specific instructions or direct demonstrations [13].

The guidelines for scaffolding include assess learners' current knowledge and experience so as to develop projects that will push them to the ZPD, make connections to what students already understand to motivate them and create momentum, provide opportunities for feedback from peers and others, make work public, and use a variety of prompts to assist students. [14].

Wood [15] identified several methods for effective scaffolding, which include gaining and maintaining the learner's interest in the task, making the task challenging but achievable, emphasizing aspects that will help with the solution, balancing between accomplishment and frustration, allowing failure with time and opportunity for recovery, and demonstrating what success may look like.

## 6 APPLICATION

This paper discusses the ZPD in terms of a collaborative design project where collaborative mentors use a student-created artefact to lead a learner to a series of "need to know" places. These places indicate the edge of the learner's independent ability or ZPD. The successful completion of the artefact requires learners to connect with a number of collaborators, courses, and disciplines, each with specific knowledge, experience, tools, or skillsets. These collaborative mentors combine to provide the scaffolding the learners need to complete the artefact in a efficient and uninterrupted path. We further discuss the advantages of extending this "need to know" impetus across course boundaries in a collaborative teaching environment, and the struggles of implementing a more complex collaborative design project.

## 7 PROJECT DESCRIPTION

This project began in the second-year studio by asking students to read selected chapters of J.J. Gibson's book *Ecological Approach to Visual Perception*. These chapters, and our subsequent discussion, provided an introduction to the concept of Gibson's ecological world and the theory of affordances. Students were required to apply this theory to the situation of opening and closing a door. If the door affords passage through a wall, and the handle affords an interaction with the door, could they affect this interaction through designing the form of the door handle?

Students were sent out to photograph door handles, which were then categorized as examples of false, hidden, or perceived affordances, the goal being to design and produce perceived affordances. After further discussion and analysis, students began to design handles that would afford certain interactions between the user and the door.

To do this, students worked through several possible form iterations using hand-drawn 2D and physical 3D sketching. These exploratory sketches and models provided a basis for discussion and critique about if and how the developing form concept afforded certain desired actions to the user. For example, if the student's concept was to develop a lever handle that was easy to use for someone with both hands occupied, then the handle needed to afford pushing down with an elbow or afford activation somehow with the user's hip, foot, or head. These affordance needs were the basis of the form generation and subsequent refinements.

After several hand-generated models, each student had a single design concept considered successful enough to continue forward. At this point in the project, the design activity shifted to a different setting and a different professor. In a concurrent 3D modelling course, students had been working on projects of steadily increasingly complexity, and now they were ready to address the door handle as an assignment in this course. Accordingly, they generated a CAD 3D model to finalize the design in digital form. They were required to print a working 3D model that would mate precisely to an existing mechanism in order to actually open and close a door. It was left up to the student's initiative and discretion to arrange printing the part either on or off campus at their own expense.

Once the part had been printed, students finished their handles to reference metallic materials and presented their final design in a critique setting. The presentation required a rendering of the handle in context, an affordance "map," and a demonstration of the handle by opening a door that was set up in class.

## 8 DISCUSSION

One goal of this assignment is to provide an extended exercise for students to practice form generation in pursuit of providing a specific set of perceived affordances. Of course the end product is secondary to the learning that takes place throughout the process. As we reflected on the points of the project at which we can identify students finding themselves in the ZPD, we were reminded that this zone is different for each individual. Therefore, it is important to have a suitably established relationship with each student in order to determine specific and somewhat customized scaffolding needs for each student. Our role as professors/mentors is, in part, to assess the students' place in relationship to the edge of their ability, and to provide an appropriate level of assistance in the form of scaffolded interventions. This intervention should not replace the struggle conducive to building long-lasting skill and understanding; in fact, it is when this struggle becomes most acute that indicates the leading edge of the ZPD. Once a student has grasped new understanding, we must then remove that temporary structure and stand ready to construct another new scaffold at the needed time and place.

Despite the individual nature of the ZPD, there are times when, as a group, most students' needs coincide. These moments can be prompted when mentor provide an explicit "need to know" to the group. In this case, the assigned reading served to initiate the project and provided background information and a theoretical underpinning for morphogenesis. Then, when we directed students to apply their new information to a specific object (a lever door handle), we provided them a “need to know.” They now had concrete motivation to explore the theory of affordances in practice and application, and to engage in difficult investigation through the application of design activity and skill. We observed that this “need to know” acted as an impelling object, guiding them to discover on their own the possible interpretations, applications, and expressions of the theory in connection with the assigned product. The project application provided students the challenge to move forward from what was accomplishable alone into the area of what they could not do alone, thus indicating the ZPD.

Further along in the project, after students had each developed handle concepts through sketching and making mock-ups, students were required to create CAD models in order to create 3D printed parts. At this point, the concentration of the work shifted from one course and professor to a different collaborating course and professor. This shift also represents a deliberate attempt to bring students as a group into the ZPD. With the requirement to print a part, our plan was to push the struggle to an acute point at which an additional scaffold was required, thus drawing on the expertise of the faculty member who now took the lead in guiding the ongoing project.

This transition was improved from the first to the second trial of this collaborative project. In analyzing our first effort, we realized it was important to provide a clear “need to know” for the students to be motivated to transition enthusiastically to the new professor and environment. Otherwise it could be viewed as a needless disruption to a comfortable working relationship. We also refined the preliminary work in the CAD course in order to prepare students more thoroughly for the coming transition.

We have determined that integrating a portion of these two courses did provide some advantages for student learning. Students reported an increase in motivation from the integration of the two courses. Some felt being able to continue along with the project into a new course was a continuation that positively linked their learning, and provided a more fully integrated understanding of design methods and activity. This perception, we observed, led to a sense that they were not just doing an assignment, but really working the way a designer works.

In our next iteration of the project, we plan to include another professor from a different discipline. We will extend the handle design project one step further to create a cast brass or aluminium part. Students will use their 3D printed handle as a pattern in the sand-casting process to make a useable end product. Our colleague, who is a manufacturing engineer, will guide the students through this section of the project. Our hope is that by taking the project further, we can provide another motivating “need to know” to coax our students to deeply learn the manufacturing process involved in creating multiple quality parts. We believe this last step will provide an intrinsically rewarding environment through incorporating factors of challenge, curiosity, control, and cooperation.

## 9 CONCLUSION

Using these few methodologies—motivation, collaboration, ZPD, and peer and mentored scaffolding—to push our student’s skills, tools, and knowledge has proven interesting. This dynamic project-based collaboration experiment is only two years old, with the second year representing a modification of the first, but it seems to be working well enough that we will continue to refine and expand the project until we find consistent results. We will then try to validate the results more accurately. We are also looking for other opportunities to challenge our students, to push them to the ZPD and build peer and mentored scaffolding to help them learn more effectively. The broader application is that we can teach new and changing competencies along with the core design skills within our limited resources. In fact, the constraints are helping us develop new and useful ideas for the education of our industrial design students.

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