Lessons from Dilbert: Clarifying Design Expectations

Learning Inspiration and Consensus through Evaluation

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Introduction

Have you ever asked someone to do something only to find out later that they did something completely different? Communication problems (e.g., misunderstandings) are one of the most common issues plaguing the workplace and classrooms *(Nowak, n.d.)*. As Technology and Engineering Educators this is something we have seen often—both in our classrooms and in those we have visited—especially when it comes to open-ended design settings, which are often "messy" and ill-defined *(Westerlund & Wetter-Edman, 2017)*. In many such instances, we have provided our students with an intentionally open-ended design challenge—hoping to be inspired by their creativity, ingenuity, and progression through a design process—only to find that students missed the mark and didn't really understand what we were hoping they would do. In these instances, the students turn in their work (e.g., design portfolio, prototype, etc.) and it becomes very clear that a communication disconnect has occurred. However, at this point, what are we to do as the teacher? We can't start

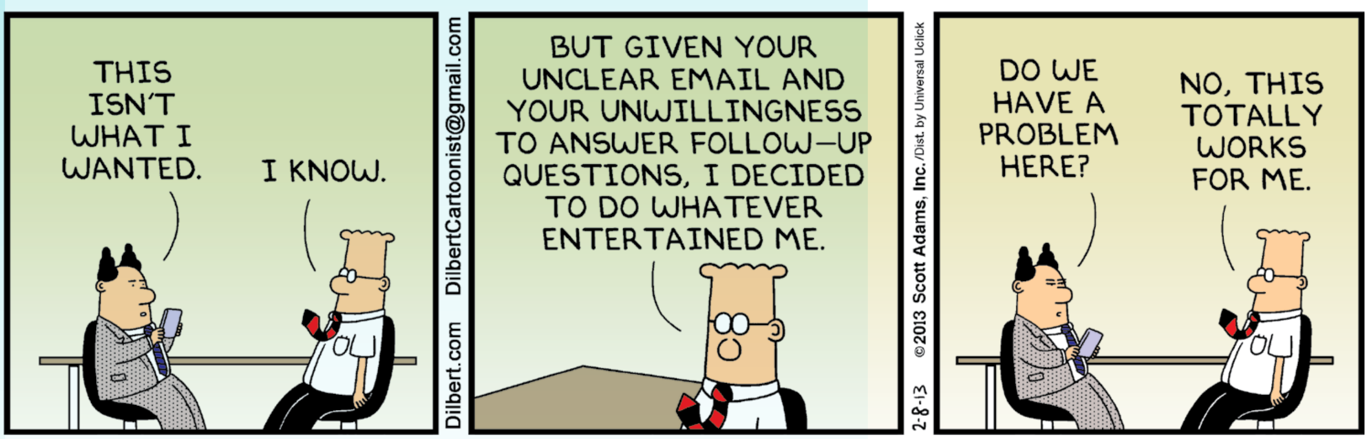

Figure 1. Dilbert Cartoon (dilbert.com)

the assignment over—it would take too much time. We shouldn't fail the whole class of students for missing the mark—communication goes both ways. So, we do the best we can to provide feedback and grades to the students. As captured beautifully in the Dilbert cartoon above (Figure 1), we are often more willing to simply move on in light of a communication failure than we are to address, fix, and work through the problem *(Markman, 2017)*.

Design in Technology and Engineering Education—The Challenge is Challenging!

Standards for Technological and Engineering Literacy *(International Technology and Engineering Educators Association, 2020)* identifies *Design* as one of eight standards driving our field; design is at the core of the *STEL* practices of creativity, critical thinking, optimism, making and doing, systems thinking, collaboration, attention to ethics, and communication. As we engage students in learning design—whether it be through a prescripted curriculum (e.g., ITEEA's Engineering byDesign™) or other approaches—a hallmark of Technology and Engineering Education classrooms is that students are actively engaged in the design process. Students are typically challenged to *do* design work from problem identification to solution presentation, all in an open-ended and ill-defined setting. By definition, this is a messy, complex space with no right answer. But there is a process (i.e., the engineering design process) and students have the potential to develop world-changing solutions *(for example, a Pennsylvania teen developed a solution to eliminate blind spots in cars to improve pedestrian safety; see Harmata, 2019)*. Still, the open-ended and ill-defined nature of the design learning experiences makes it hard for teachers to lay out clear expectations and guidance for students without over-constraining student thinking or having the miscommunications described earlier. *As educators, how can we better communicate expectations at the start of each design challenge?*

Design challenges can overwhelm and paralyze students who struggle to see how the challenge might be solved. Students may feel they could never develop a solution to the problem because it is too challenging, and, as a result, may not even try. However, as teachers, we know that students are able to develop solutions and we often may even have a "library" in mind of many previous creative solutions. *As educators, how might we foster design self-efficacy in students?*

Over the years, Technology and Engineering Education (TEE) teachers become experienced at recognizing good design work and can identify it when they see it. However, even with a solution in mind, students don't have this luxury and are often left to wonder what their products and processes should look like. With all of these questions, some students can shut down if they feel they are not able to be successful: What is valuable? What is not? Which direction should I take and how should I represent my design in my portfolio? Should I be taking risks in developing ideas that are innovative or be more cautious about making sure the product works by using well established materials and processes? Should I focus on documentation, product form, function, or all of these?

As teachers we often explain our expectations as we introduce the design brief. While students might actually be listening, students may have a hard time internalizing these expectations without context. If students don't (or can't) internalize how their work will be evaluated, what is important (and not), and what "good" looks like, they will struggle to generate good work or sometimes exhaust their efforts on the wrong aspects of the project. *As educators, how might we promote student evaluation skills so that students can evaluate their own work as they progress through the design process?*

Learning by Evaluating

To address these concerns related to design education, the authors are piloting a design primer called *Learning by Evaluating*. The concept of Learning by Evaluating (LbE) arose from work in assessment—specifically, assessment using a technique referred to as *adaptive comparative judgment* (ACJ). A full description of ACJ, its underpinnings, and the associated findings is beyond this piece, but the reader is encouraged to look at Pollitt *(2012)* and Bartholomew *(2018, 2022)* for a more complete description. It is important that we highlight one key finding of the ACJ literature: the power of comparisons. Research over the years has consistently shown that humans are more comfortable and reliable when making comparative decisions than when making subjective decisions. For example, there's a reason that an optometrist shows you pairs of different prescriptions and asks you to choose the clearest of the two—if they simply showed you all the options at one time and asked which lens was the right one, your ability to decide would be severely hampered, in both ease and reliability. We highlight this aspect of ACJ because there is power in paired comparisons above and beyond the benefits that may come from simply viewing examples of previous work (such as in a gallery walk). As authors, this connection between ACJ and LbE and the power of paired comparisons was almost accidental—while studying methods for improving assessment techniques of

Figure 2. A student using ACJ to evaluate peer design work.

teachers, students were engaged in the practice of evaluating their peers' work in a paired fashion (through ACJ; see Figure 2).

Originally, students were engaged in these evaluations as a means of investigating how their evaluations compared with those completed by the teacher; however, we quickly noticed that this practice of asking students to evaluate peer work was influencing them. Students began to notice the details in their peers' work (good and bad), they were developing the ability to discern between "good" and "better," and they were picking up on the vernacular used in design (e.g., describing subtle differences in their peers' ability to "identify criteria and constraints" or "produce a functional prototype"). These benefits were strengthened as students were asked to verbalize (or write out) their own thinking while they evaluated these consecutive pairs of peer work and selected the one they perceived as "better." The authors' research *(Bartholomew et al., 2022)* identified four main benefits of engaging students in this evaluation experience *as an intentionally placed primer for learning in a design setting*, these include:

1. Students are exposed to previously completed work, helping them "set the bar" and clarify expectations around the assignment.
2. Students identify positive and negative qualities that they can later use in their own designing.
3. Students learn the "language of the field" as they use design-specific terminology to describe why one item is "better" than another.
4. Students solidify their own understanding of design elements as they verbalize (or write) these down in their justifications for choosing one item over another.

Building on these findings, funding was applied for and received from the National Science Foundation to test this instructional approach further with K-12 students (NSF Grant #2101235). Specifically, the authors have been working with teachers and students in the greater Atlanta area (Georgia, USA) enrolled in an introductory high school design class (EbD *Foundations of Technology*). In these classes, LbE has been situated as a primer for design learning in a variety of settings, projects, and classrooms—we are continuing to explore what works, or doesn't, and why. Some of the preliminary findings, observations, and experiences are shared in hopes that more classroom teachers can implement LbE with their own students.

Learning by Evaluating—How To

Three main pedagogical elements of incorporating LbE as a primer in the learning process are suggested:

1. Introducing and orienting students
2. Engaging students in a series of comparisons
3. Leading a classroom debrief

Each will be discussed in context of the Engineering byDesign *Foundations of Technology* Unit 5 preliminary challenge: Park Design with Community Connection. In this challenge, students demonstrate their understanding of design while using CAD software to model a community park.

STEP 1. INTRODUCING AND ORIENTING STUDENTS.

Instead of other work that emphasizes assessment at the end of a design process, we propose situating LbE at the beginning of a design challenge, just after providing the students with the design brief and prior to students beginning any design work. The first element of LbE is to introduce and orient students as preparation for them to engage in a series of comparisons. The teacher might ask a few questions (perhaps hypothetically at this point) such as what makes a good community park? What does our community need in a park? What are key features of a community park? How might we best communicate our design intentions to share our park design? After sharing a few questions to prompt students to wonder how their park might look and how they might engage in designing their park, the teacher can show students two park designs side by side and ask which is better (Figure 3 as a potential example). Some students might identify the park on the top because it is more colorful or the park on the bottom because it has more green space.

STEP 2. ENGAGING STUDENTS IN A SERIES OF COMPARISONS.

After a teacher-led discussion on the qualities of different parks and some whole-group classroom comparisons (e.g., using Figure 3), the teacher can engage the students individually in a series of comparisons. Students are provided with access to several pairs of park designs and asked to evaluate them by identifying, of the

Figure 3. Two images of a park for discussion (Whiting, 2021).

pair, which is best. Student decisions should be guided by a predetermined criteria (i.e., called a holistic statement or prompt) from which they determine which of the two designs is better. Example criterion could include ideas such as:

1. Which is more "family-friendly?"
2. Which is more attractive?
3. Which is safer?
4. Which provides better parent supervision ability?
5. Which could support a wider age group?
6. Which might be easier to maintain?
7. Which fits our community better?
8. Which is more exciting?

After each comparison, students are asked: "why"? This provides them with an opportunity to justify each decision of one over the other with evidence and reasoning. Because there is not a right answer in these questions or between the examples provided, students are challenged to think deeply about what matters and explain why.

STEP 3. LEADING A CLASSROOM DEBRIEF.

After the students have had a chance to individually consider what makes a "good" park for a community, the teacher can facilitate a classroom discussion to both elicit and solidify the concepts noticed by the students. We suggest returning to the original questions posed hypothetically in Step 1 (i.e., What makes a good community park? What does our community need in a park? What are key features of a community park? How might we best communicate our design intentions to share our park design?). At this point, students can verbalize, and internalize, key elements of existing design work that might serve to inspire them creatively while also helping them recognize "good" design work. With this solidified understanding of their value structure, what matters in design, we hypothesize that their design experience will be more informed and thoughtful.

We also anticipate that, in some cases, the class and the teacher may have discrepancies in their values that are revealed by the comparisons and discussion. These differences are not necessarily "right" or "wrong"—often they are simply an expression of a different understanding, background, and "lens" through which the design challenge is viewed. For example, there may be students in the class who thought the park shown on the bottom in Figure 3 was better. However, perhaps the teacher thought they had been emphasizing an ADA-accessible park for which the grassy field may not be compliant. Alternatively, some students may have identified the park on the top as better, while the teacher was envisioning a community gathering place at the park for children (and adults) of all ages. These differences in perceptions of "needs" and "emphasis area" are valuable and positive—they provide opportunities for classroom discussion and the solidification of design criteria and constraints. While TEE teachers typically specify expectations in a design brief, students may or may not be able to operationalize what these mean in practice and the teacher might not be aware of this miscommunication. By engaging in a discussion about which is better and why, the students and teacher are able to establish a clearer understanding in preparation for design work.

Ok Cool—I Want To Try It—Which Button Do I Push?

Three tools are suggested to bring this comparative experience to your classroom on Monday morning: Google Slides, No More Marking, and RM Compare. Each approach has benefits and challenges. Which might be best for you?

GOOGLE SLIDES:

At the simplest level, the teacher might put together a slide show where each slide is numbered and has two images (student interface shown in Figure 4). With a label for each image on the slides, A or B, students can write down (on paper or electronically) which is better, A or B, and why. While this approach is quick and easy, it yields no analytics on student responses, nor does it automate the capturing of student decisions and/or rationales.

NO MORE MARKING:

No More Marking is a website that facilitates comparative judgment for schools with free accounts for educators (at *www.nomoremarking.com/*). The student interface is shown in Figure 5. The advantage of this tool is that the interface facilitates the paired comparisons, and the teacher is provided with a ranked order of the results (includ-

Figure 4. Google slideshow student interface.

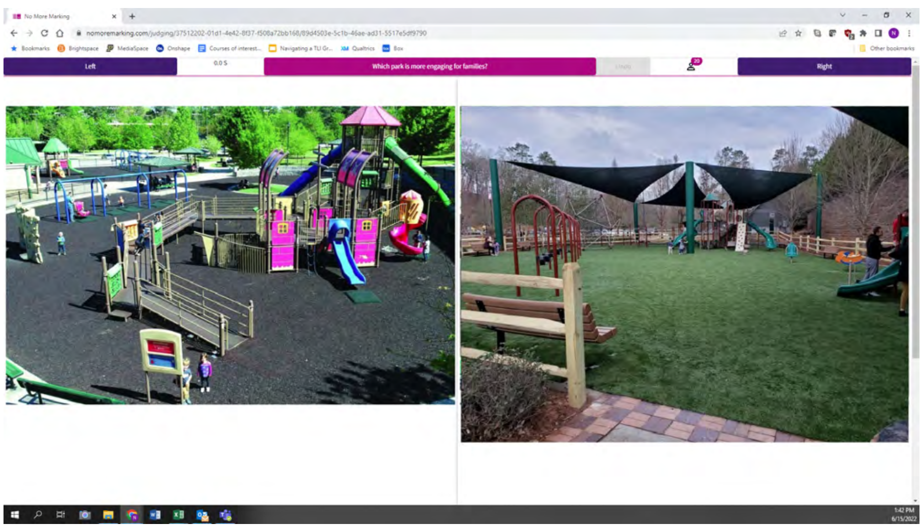

Figure 5. No More Marking student interface.

ing student comments), which may be informative for the debriefing discussion to identify which items were considered best and worst by students. Comparison items are limited to PDFs and need to be oriented in "portrait" page layout. Note that the system is not password-protected, which means the login is easy, but anyone with whom you share the link can access the contents of the session.

To set up a session, teachers should create a free account and then select "Create a Custom Task." In the "General" settings, the task can be named, the prompt for the judges (students) can be posted, and instructions for the judges (students) can be entered in the field named "Judge info." Toggle "use codes" to "no." The rest of the settings on this page can remain as the default. Be sure to use the "update" button at the bottom of the page to save your settings. Next, click on "1 c. Scan Completed Assessment and Upload" and select or drag and drop PDF files for students to compare. Then, click on "2 a. Run a judging session" and estimate the number of judgments you would like each student to make. Note that the "candidates" are your items to judge (PDFs you just uploaded), and the "judges" are the number of students you have in class. Experiment with the number of "candidate judgments" ("how many times will each item be judged?") until you get a reasonable number of judgments per judge ("how many times will each student be prompted to compare a pair of items?"). Hit the "adjust" button to update. When ready, copy the link provided and share with students! Students can select the top middle banner (the prompt text) to leave comments about each item explaining their decision and then select the left or right side of the banner to indicate their choice of which is better.

After students engage, the teacher can click on "3 a. Check your results." "Refresh task" first and view the rank order. Results can then be sorted by scaled score to see the rank order with the scale value being a relative measure of how different each item was from the others. The "Infit" measure of an item indicates the extent to which judges (students) are consistent in their decisions comparing items where lower numbers indicate more agreement between judges on that item. For additional information, the teacher can navigate to "2 a. Run judging session" and "refresh task" to see who judged, how much time judgments took, and judge (student) "infit." Infit for a judge is a measure of how consistent that student is with others, where 0-1 is consistent (this student agrees with the majority) and a higher number is less consistent. Controversial items might be a great place to start the debrief discussion: What can be seen in each image that informs our design? Students with higher infit scores (meaning they don't agree with their peers) might be a great place to either reteach (if they don't understand the expectations) or learn unique insights for the class (as they might be "thinking outside the box")! Use the "My Tasks" (and then select "custom tasks") button to return to your dashboard.

RM COMPARE:
RM Education offers a software interface called “Compare,” for which the student interface is shown in Figure 6. This interface is custom tailored to facilitate adaptive comparative judgment and provides a well-developed user experience including a mobile-friendly platform. It requires a login to facilitate secure access for students and teachers. The interface offers a variety of analytics for teachers to rigorously interrogate student decision data. A limited free version is offered at https://compare.rm.com, with a paid subscription available. To get started, log into your account and select “Create New Session” and name the session. In the “Overview,” “Settings,” “Basic” tab, the session can be named and described, and the holistic statement (prompt for students) can be entered (don’t forget to “save changes”). Under the “Feedback” tab, student comments explaining their decisions can be enabled at the comparison level or the item level. In the “Judging” tab, students can be permitted to see results and upload their own items for comparison. Next, in the “Add Judges” Tab, judges (students) can be invited by email, reused from a previous session, or uploaded from a CSV file (which could be exported from your LMS software). In the “Add Items” tab, webpages, images, PDFs, videos, or YouTube videos (note RM Help for YouTube video link formatting) can be uploaded for evaluation. When ready, “Run Session.”

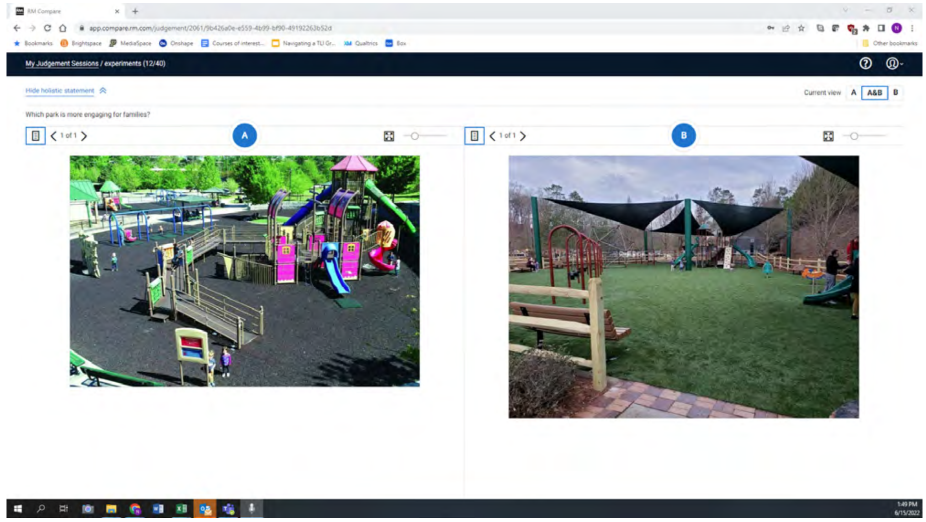

Figure 6. RM Compare student interface.

After students make comparisons, the teacher can review a variety of data including an overview in the form of a report. From the “Reports” tab, choose “Show Report” to access a rank order with reliability (“how confident are we in the results of this session?”) and parameter values (“how did each different item compare to the others?”). “Judge Misfits” shows visually and numerically the extent to which each judge agreed with the others (lower numbers indicate stronger agreement). “Item Misfits” indicate the extent to which judges (students) agreed on individual items with lower numbers, indicating stronger consensus. With these data, teachers know which items the class thought were better, why, and if any students rated items significantly differently than other students or if any items were controversial.

> “As educators, how can we better communicate expectations at the start of each design challenge?”

Conclusion

As authors and TEE teachers, the authors have been experimenting with the LbE approach since 2016 in a variety of elementary, middle, high school, and university level courses. Positive findings across grade levels have shown the potential for using LbE to improve design experiences for students. However, we noted two specific challenges while working with the teachers and students. One involves selecting the right items for students to compare, coupled with the right criterion statement, and requires some effort. This effort can be mitigated in part by using student work from a previous semester, but to be precise, what needs to be communicated to students requires deliberate (not Dilbert) choices about which items explicitly illuminate the features that might address student misunderstandings. For example, a teacher who notices that students are struggling with the identification of criteria and constraints will need to carefully select examples for comparison that highlight both positive and negative examples of this identification. This collection process for paired comparisons can be intense in terms of effort and time required for successful completion.

Another challenge uncovered in teacher discussions is the worry that students might simply copy what they see on the screen in the paired comparisons for their project. In essence, the students may think they are being shown the "right" answer and their job is to duplicate it, which is not a good example of engaging in the design process or fostering creativity. Helping students to overcome this temptation will likely require teacher intervention and explicit direction (e.g., during the debrief section of LbE). Moreover, by seeing a variety of "good" designs, and even variety in the characteristics of those designs, we think students can be encouraged in their own process.

Despite the challenges associated with LbE, overall, the required time and effort to implement LbE in the classroom is minimal. Following the first year of investigation within Grade 9 *Foundations of Technology* under the NSF grant, two main benefits to the approach were noted:

First, this approach supports the teacher and students in converging on a shared understanding of expectations, helping to answer the question, "What does a good one look like?" This clarifying experience can help avoid the *Dilbert* miscommunication trap outlined above. A shared understanding of "good" helps all in design education settings.

Secondly, this approach can also support divergent thinking. Specifically, LbE is useful for fostering creativity in students in that, as they view pairs of previous work, their own thinking, creativity, and understanding of possibilities are expanded. In this way LbE is helpful in answering the question, "What *could* a good one look like?" Further, exposing students to a variety of ideas may be helpful in overcoming design fixation—a problem commonly encountered with students.

TEE teachers are encouraged to consider opportunities for LbE in their own classrooms using one of the three approaches outlined above. Clarifying expectations and avoiding Dilbert-like experiences in classrooms will make the learning experience better for teachers and students.

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