

# Transformative Learning in Client Based Research Projects

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## Abstract

*Using client-based research projects can be a difficult but transformative learning experience in introductory courses. This essay incorporates three voices: a research client, a student, and the course instructor and explores the transformative learning of each. Each person shares the disorienting dilemmas he or she faced in a course that encouraged productive failure. Productive failure on a client-based research project as a feature of transformative learning is the innovative and key element of the introductory course. The shared dialogue among the client, student, and faculty member illustrates how transformative learning leads to better course design and enhanced student learning.*

*Keywords:* project-based learning, productive failure, transformative learning courses

## Transformative Learning in Client-Based Research Projects

Project-based learning (PBL) allows students to see the connection between concepts presented in class and their application in the real world. Today, faculty frequently adopt a pedagogy that includes PBL rather than straight lecture reporting increased student engagement, motivation, and academic gains (Perrenet, Bouhuijs, & Smits, 2000). Many faculty members scaffold their PBL so that students can achieve success. Instead, this paper examines the role of failure in project-based learning and its relationship to transformative learning theory. The sequence of steps in transformative learning theory: experiencing a disorienting dilemma, critically reflecting on the dilemma, engaging in dialogue with others, and developing an action plan (Mezirow, 1997) provide tools by which students can transform failure into success. We suggest that adopting transformative learning techniques and allowing students to experience productive failure leads to greater student confidence and the acquisition of important project management skills.

Typically, introductory courses use carefully scripted projects to teach students ideas and skills while methodically working through new materials. Such projects are unlikely to mirror real-world experiences. This essay explores an alternative approach, the incorporation of

undergraduate research projects into an introductory course. When students encounter non-scripted, client-designed projects in an introductory course, it can be disorienting, but also lead to a transformative learning experience. College students who tackle real-world projects for the first time often are surprised by the clients' expectations regarding required levels of communication, academic skills, and knowledge. Students accustomed to success in traditional classroom settings become rattled when their skills and knowledge are not sufficient for the task the clients want them to complete. They may begin to perceive the project as a failure.

Similarly, outside clients who agree to have work done by these students may overestimate the students' abilities or skill level. Clients may think they are receiving free help from a well-prepared student team with current skills and knowledge. When the student team fails to communicate, does not grasp the work, or are simply missing the necessary skills, the client becomes frustrated. When the client's expectations are unmet, students also may perceive the project as a failure. Both the experience of perceived failure and the ability to work through this experience are at the core of transformative learning.

The careful design of an undergraduate course that includes a research project, along with the management of student and client expectations, can facilitate transformative learning. Undergoing this transformation enables students to move forward confidently and clients to feel good about participating in an important learning process. By incorporating three voices: a research client, a student, and the course instructor, we explore how expectations, definitions, and experiences of failure enhance PBL and become the building blocks of a transformative learning experience.

### **Literature Review**

To understand the motivations and context of the course, we first examine how it fits within the curriculum. The course discussed in this study is "Introduction to Data Science," the first disciplinary course that data science majors take, although it occurs during their 2nd (or later) semester at the university. Thus, students have not (necessarily) spent time understanding what the field of data science encompasses. Typically, they have some vague ideas, based on pop-culture, other courses, or secondary education in mathematics, statistics, and computer science.

Whether or not students understand what data science is, they all enter the course lacking "data acumen," a skill widely accepted as a necessary component of data science education. Data acumen refers to the ability of students to "make good judgments, use tools responsibly and effectively, and ultimately make good decisions using data" (Committee on Envisioning the Data Science Discipline: The Undergraduate Perspective et al., 2018). The 2018 report from the National Academy of Science, Engineering, and Medicine (NASEM), and other literature hypothesizes that the best way for students to develop this skill is through projects working with real data. Typically this occurs in upper-level, capstone style, or graduate courses (Saltz & Heckman, 2016). However, in designing the course, the professor felt that through a *transformative project-based learning experience*, students' acquisition of data acumen could begin earlier.

Regular use of project-based learning in upper-class or capstone projects is due to several features (Balzotti & Rawlins, 2016; Cooke & Williams, 2004; Kramer-Simpson, Newmark, &

Ford, 2015; Rice & Shannon, 2016). Project-based courses engage students because they contextualize new learning (Corbett & Hill, 2015; Hill, Corbett, & St. Rose, 2010) and present realistic problem cases. Project-based courses motivate students to enhance their knowledge and acquire twenty-first-century skills (Savery, 2006). Twenty-first-century skills as identified by the Partnership for 21st-century learning (P21) include creativity and innovation, critical thinking and problem solving, flexibility and adaptability, initiative and self-direction among others (Partnership for 21st Century Skills, 2009). By completing projects, students construct a personal portfolio of examples to draw on in future endeavors (Helle, Tynjälä, & Olkinuora, 2006). All of these aspects make PBL fit extremely well with its typical placement in advanced or capstone courses.

Despite the benefits of PBL, there are many challenges to using it in introductory classes. Butler and Christofili (2014) talk about the lessons they learned when introducing first-term college students to PBL. They describe a situation in which the final project was incomplete. Course integration was therefore limited, and students resented others for not doing their fair share. Based on their initial failures when using PBL, Butler and Christofili suggest projects need to be well defined, laid out systematically, and interesting to students, for PBL to succeed. By the third time they taught the class, they provided students with more preparation at a lower level, included more systematic and detailed instructions, and more slowly decreased their hands-on support. Scaffolded problem-solving activities with a gradual reduction in supports as students gain expertise is paradigmatic of PBL (Puntambekar & Hubscher, 2005). Butler and Christofili's (2014) experience show the progression from students experiencing minimal learning, either immediately or long term, to a design that helped students master the short term content and retain it for future use.

Performance on a project is not always a good indicator of how much one has learned. Kapur (2014, 2016) argues the disparity between learning and performance may have at least four outcomes: productive success, productive failure, unproductive success, and unproductive failure. In the context of PBL, "failure simply means that students will not be able to generate or discover the correct solution(s) by themselves" (Kapur, 2016:289). Meanwhile, many scholars have touted the educational benefits of productive failure (Ferrandino, 2016; Kapur, 2014, 2016; Lai, Portolese, & Jacobson, 2017; Leong, 2013). Both productive failure and productive success maximize learning in the long run. Productive success also maximizes performance in the short run while productive failure does not. Essentially, Butler and Christofili's (2014) experience describes the movement from unproductive failure to productive success. While they ultimately achieved productive success through PBL, we propose that designing a course to take advantage of productive failure may be better for introductory course design within a major.

Introductory or foundational courses typically prepare students to do more extensive work within a discipline. Productive failure by design forces students to work together to use what they know in new ways. It may result in less than ideal deliverables, yet the process is often helpful in preparing students to work on future projects (Kapur, 2014; Kapur & Bielaczyc, 2012; Schwartz & Martin, 2004). Thus, productive failure is especially helpful in foundational courses where one student learning objective is: preparation for learning from subsequent instruction (Kapur, 2016). Additionally, productive failure may better mimic future work environments and give students the opportunity to develop important work management strategies. One way to

incorporate productive failure into projects is to use transformative learning theory in the course design.

Transformative learning emphasizes a paradigm shift (Mezirow, 1997) which helps students perceive success and failure differently. A transformational learning experience includes four key steps. The first two steps are a “disorienting dilemma” and “critical reflection” (Mezirow, 1997). Transformative learning requires critical reflection to make sense of the dilemma or perceived failure. To conclude the transformative learning experience, the third and fourth steps: dialogue and action are required. Through dialogue, the learners process their reflections and begin to reframe the failure experience. Typical actions that follow the dialogue include planning changes, acquiring new knowledge and skills for implementing the plan and building new competencies.

Transformative learning is a progression by which individuals move from discomfort and perceived failure to successful and productive future action. And while most of the literature focuses on students, transformative learning may be applied to clients and teachers (Swanson, 2010). Disorienting dilemmas are those that are unfamiliar to the individual. For students, and potentially for project clients, dilemmas include perceived project failure, unresolved communication issues, and behavior that does not conform to typical client-provider models.

Perceived failure is uncomfortable yet necessary. The discomfort lets the individual know that their traditional ways of operating are not working. If there were little to no discomfort, an individual would continue as he or she always had. Perceived failures motivate students, faculty, and clients to question their knowledge and think about new ways of problem-solving and working. The process of questioning and thinking about new ways is described by Brookfield (2015, 1995) as a model of critical reflection, which is similar to the dialogue step in the transformative learning model.

The critically reflective dialogue step asks individuals to examine their assumptions and actions from as many different perspectives as possible (Mezirow, 1997). When one shares one’s thinking with others, it helps the individual make sense of experiences, particularly those that are disorienting. In the following section, we illustrate this process of making sense of our dilemmas. Each author experienced some disorienting dilemmas as part of our work in this class. Each author has also critically reflected on his or her actions. Through the letters that follow, we replicate the dialogue process. The final section summarizes this case and the transformative learning that occurred.

### **Shared Dialogue and Critical Reflection Letter from a Client**

Dear Professor and Student(s),

Thank you for welcoming me and my project into your class. Through this letter, I will share my initial thoughts, critical reflections, and new thinking. Trying to recreate dialogue is hard but I think that if I share what I learned and how talking with you helped me see things differently, it might help others in the future. First, let me say that I was excited to learn that students were interested in my project. I anticipated that the students in this class would have statistics and database management skills much greater than my own. I also assumed they would be eager to learn more about student cheating and working on a real research project.

As I reflect, the project started well. I worked with three students who appeared eager to learn. We met initially in my office, and I gave them an overview of the project, explained what I hoped they would be able to do, and provided them with my data and some other resources. Getting more advanced statistical analysis of my data and having students think through questions about why high school students cheat were the outcomes I hoped to receive. After an initial meeting where I shared my goals for the project and some background materials, we agreed to meet every Friday.

Meetings quickly became the first dilemma I experienced. After the initial meeting, I'm not sure all students were ever present at a meeting. Sometimes two would show up, at other times, only one. I did not receive much communication from them regarding meetings or their progress. At most meetings, the student(s) did not have anything to show me. To me, that meant no progress. I was eager to see their analysis and talk about the meaning of the analysis, issues they may have uncovered, etc. Instead, progress was slow, and I did not receive any analysis that was particularly meaningful to me. In retrospect, Fridays proved to be a bad day to meet. I had to miss two or three due to conferences. Students sometimes needed to go home for the weekend and left on Friday. Eventually, there were large gaps in time between meetings.

Finally, I asked the one or two students who showed up for a meeting that occurred about 6 or 7 weeks into the project to tell me more about their work on the project. The students explained that there was little time in the class devoted to project work. With the other demands from this course, as well as their other classes, they were finding it difficult to get work done.

The second disorienting dilemma for me centered on student output. Because I did not see evidence of their work, I eventually gave up hope that I would receive any useful analysis from these students. I knew they were under stress and guessed that they felt bad about not providing me with more results. Upon reflection, I wish I was more direct with them. I was a client hoping to receive free statistical help on my project. I did not view the students as novices but rather as individuals who possessed advanced statistics and database skills. I failed to consider how little they might know about working with a client.

Through conversation with the professor after the class ended, I realized my mistake. If the University had a sign out front reading "Data Scientists in Training," I would have entered into this project differently. I would have realized that getting free help from people in training means I may not be totally satisfied with the output. I approached the students as if they were professionals with advanced data science and project management skills. As a client, I took a risk asking for free help from novices. I now see these students as learners in need of experience from which they can learn about data science AND about how projects using data may be constructed and developed 'in the real world.'

The role I wish I had played would be less 'client seeking solution' and more 'client paying it forward.' I hope that the relative failure of the project in terms of providing me with expert data analysis still taught them valuable lessons. I realize that students need to develop project skills such as clarifying client expectations, arranging manageable deadlines, and communicating regularly about their progress.

The dilemmas of losing valuable work time to unproductive or canceled meetings, not getting what I thought I'd receive, and realizing that my unrealistic expectations played a significant role in the project's failure will help me approach future contracts with students differently. I will ask more questions and clarify my role. I hope to create an environment in

which I can share the context of the project while they share their knowledge of statistics and database management systems. It is likely I will assume more of a managerial role and require meetings as well as proof of their work each week. I will seek to determine the level of knowledge of the student(s) and then assign tasks accordingly. I will also ask the student(s) how I can help them, and we will negotiate the workflow together.

### **Professor Letter**

Dear Colleague,

As you consider running a client or project-driven course, I hope you will take a few minutes to consider some advice based on my experience. My course, *Introduction to Data Science*, was designed for beginning students, typically freshman and sophomores. It also typically enrolls several upperclassmen from various disciplines. All enrolled students are new to the field of data science. It can be challenging to design content for such a mix of students.

I included client projects, to expose students to the full data-science cycle, including addressing questions posed by a client. By experiencing the full cycle, students realize that what matters more often to the client is the summary and explanation of results. The actual mechanism for producing the results is often less relevant. Most students have previously seen data as something to be used in computations. They see math and statistics as operations to be applied to problems. A full-cycle project emphasizes the need to understand “why” the data answers the question, “why” results have meaning, and more. Shifting one’s perspective from the mechanism (or “how”) to a focus on the result (or “why”) presents students with a mental dilemma. This dilemma can lead to a transformative learning experience that prepares them for future courses and professional environments.

The successful implementation of this design turned out to be far more challenging than I anticipated and involved much more than simply including projects. After two semesters of teaching the course, I have experienced as much transformative learning as my students. Originally, I believed that after I solicited projects and assigned teams, everything would run smoothly. I could provide students with a clear set of deliverables, a grading rubric, and due dates. Then the students would be able to take what they learned in class and apply it. Traditionally, in successful projects, students deliver a product or report that addresses the client’s (actual) needs and questions. Here’s my dilemma: using this model, only about 1/3 of the conducted projects were “successful.” When so few of the projects were “successful,” I realized there was a definite problem in my course design and delivery.

Another dilemma I experienced was that while the students achieved the learning goals I had for the project component, the students and clients often felt the projects were a failure. Even productive failures felt frustrating for students and clients. Clients were disappointed that they invested time and energy, yet, received minimal or no actionable/usable work. Students often felt they had failed, were concerned that their grades would be poor, and generally were unsatisfied. This frustration and disappointment was a major dilemma for me since, as designed, the projects in my course did not satisfy two of the major stakeholders. Let me provide an example.

One project was for a non-profit interested in knowing how long after a flooding event a house foreclosure happened. I had extensive conversations with the client and felt the question was reasonably specific and manageably scoped. It turns out that unique flooding events are

difficult to identify. Moreover, when looking at foreclosure data, the housing market crash of 2008 and the annual cyclic behavior of seasonal foreclosures far outweighed any evidence of foreclosures from flooding. In this case, the clients did not receive an answer to their question. The students worked very hard, yet, failed at answering a seemingly simple question.

Did something go wrong with this project? That is a matter of perspective. The students did succeed in “answering” the client’s question. The answer was simply negative about being able to predict foreclosures from flooding data. To view the project as a success required me to manage both student and client expectations. Could a different outcome have been achieved? Possibly, and for that, I want to pass on some more explicit advice.

Originally, I included client projects as a mechanism for increasing engagement and providing a target to apply the knowledge and skills students were learning. I thought the far more “important” part of the course was the traditional content that covered data science algorithms, data types, etc. After one semester, it was clear this was not entirely true. Therefore, I included a full lab day each week for project related work. After two semesters, I have come to realize I need to shift how I teach the course. I need to transform the design from being focused on data science knowledge to focus on the data science *project* life-cycle. I will be implementing several changes to both the content (more on project management, group dynamics, etc.), and how I run the class itself (include upperclassmen or graduate students as ‘project managers’). If you would like more details, I would be happy to share them.

## Student Letter

Dear Future Student,

In this letter, I will address the primary disorienting dilemmas of Project Based Learning as well as the transformative benefits I experienced. Entering college, I had a predisposed idea of what an “introductory” class should entail. These classes should include background details on the subject, surface-level descriptions, and controlled learning environments. However, I have come to realize that the unique PBL design of this course was beneficial in several ways.

Having very limited knowledge of data science, I was nowhere near ready to handle a project with an outside client. Reporting to professors and meeting academic standards have never been issues for me. However, dealing with real-life clients is much different. Outside clients do not have the same investment in your success as the university staff. I learned this very quickly. What my professor expected was primarily structured around meeting project deadlines. From the perspective of a student/teacher relationship, these guidelines seemed reasonable and achieving academic success was possible. Working with outside clients was not as simple.

Upon reflection, there is one key takeaway from the first dilemma I faced in the Introduction to Data Science course. This takeaway is that you absolutely need to understand your client and they need to understand you. This understanding includes their role in the company, their availability, and how valuable your project is to their future success. Client expectations differ, so setting realistic expectations are crucial. The client needs to understand that, although their project is important to you and you are shooting for successful outcomes, it is not your job. They need to be cognizant of your academic workload, as well as the fact that you can only dedicate a set amount of time to their project. Part of this responsibility falls on the professor in project establishment, but part of it falls on the student to be transparent with the

client. It is essential that the client and student are on the same page at all times throughout the semester.

During my project, I failed in understanding our team's client. Specifically, I failed in understanding our client contact. Our client assigned a contact person with limited knowledge about the topic to work with us. Thus, a majority of the key decisions about project direction became subjective interpretations on our part. For students, not knowing the answers and feeling completely alone in figuring them out can be incredibly frustrating. Looking back, I have come to realize how different the project outcome may have been had our team known more about our client. While the client lacked knowledge about data, they may have been able to provide insight into other aspects of the company or created a bridge between our group and an employee contact better suited for our task.

My second dilemma, a lack of clear communication and power dynamics, flows from the first dilemma. When communicating with professors, addressing issues and sharing your feelings about course workloads is simple. However, with outside clients, these simple conversations seem incredibly daunting. A majority of this is due to the inherent power dynamics of a client-student relationship. These power dynamics were one of the main causes of communication failures. Students tend not to challenge the clients' wishes, making it increasingly difficult to communicate honestly. Clients expect you to achieve a level of success similar to that of a paid employee unless you tell them otherwise. Be reasonable about your availability and be honest about your expected commitment to the project. Had our group had more transparent communication and an equal relationship with the client, our work would have felt far more valuable.

The final dilemma I experienced had to do with the value of our work. We perceived that our project had little real value for our client. It is crucial that students feel that their work is meaningful. For my team, our project seemed incredibly trivial in the scope of our client's company. The client made no effort to schedule meetings, did not have any interest in hearing about our progress, and never seemed to care about the work we were doing. The lack of attention only reaffirmed my feelings of inadequacy. I struggled to find ways to be useful in the scope of a seemingly useless project. I looked to our client for instruction and was incredibly disappointed. I firmly believe this led directly to my failures in this project. At the end of the day, as "consultants," our job is to problem solve independently of the client. Had I understood that independence should be embraced rather than passively accepted, the project would have been much more beneficial for me. Instead of making excuses for lack of progress due to poor client leadership, I should have taken what I was given and run with it to create my own success.

After reevaluating the causes of my dilemmas, I have come to realize how much the course taught me. Despite my frustrations over the dilemmas I faced, I learned that the real world is messy. Clients can be unreliable, expectations can be unfair, and equal-opportunity communication is rare. To me, these lessons were key to my success in the year after this class. PowerPoint presentations and a clean, controlled project could not have taught me how to respond to real-life scenarios. Combining academics with the outside world is crucial to truly learning how to succeed in the workforce.

During an academic year, it can be difficult to see personal growth. Often, it takes another experience for an individual to realize how much they benefited from past experience. For me, that was precisely the case. At the time of the course, I felt only frustration with my



progress. However, after reflecting on my dilemmas and discussing the learning with my professor, I am more ready to enter a summer internship.

Knowing I have experience in dealing with clients, I feel ready to enter the business setting. Critically reflecting on my past communication failures will allow me to interact with my future boss as well as other business professionals both maturely and confidently. For me, that confidence is where I felt the most transformative growth. The class allowed me to become confident in the course material as well as in my interpersonal communication skills. I have overcome the dilemmas of understanding a client, communicating clearly and fairly with someone of equal or greater professional status, and perceiving true value in my work. I feel confident in facing future professional settings without fear of failure.

### **Conclusion**

Within this project, the student transformative process is U-shaped. Students often enter the class buoyed by their previous academic successes and excited by research projects which put them in the roles of employees with a needed skill set. Their confidence is high. However, as McEachern (2001) states, client projects challenge students in ways that “not even the best-written case study or end-of-the-textbook-chapter-exercise can duplicate” (p. 211). Students wrestle with research questions that are ill-defined, have failed directions of investigation, and require initiative or unique thought. Client projects can cause students’ confidence to plummet as they realize they are missing skills needed for work in the ‘real world.’ By setting the research project amid a full course, students can receive support and guidance in rebounding from an initial realization that they do not yet possess real-world level skills.

Moreover, we observed that by exposing them to this drop in their perceived abilities, then helping them reflect on the experience, students gain important maturity, insight, and skills. These gains enable them to successfully implement deeper projects in their junior and senior years. Thus, they transform from overconfident novices to realistic, skilled students.

For the instructor, transformative learning occurs when careful attention to student and client perspectives is used to design the entire process. The instructor has to work with both students and clients to reframe failure and learning. Reframing is vital to supporting a successful transformation experience in which everyone retains enough confidence to engage in future projects. Successful transformation is accomplished for the student, in part, through an academic grading method that weighs skill development and gains in knowledge along the way more heavily than the final deliverable given to the client. For clients, the instructor must help them see their role as part of the students’ learning process, as well as help them formulate realistic expectations about student work.

Clients enter the course with a variety of expectations. Some hope to receive ‘free’ help with thorny database or project issues while others simply want to work with students who may have the knowledge they do not possess. Given the client’s reflection above, the reader might wonder if it is worth the personal capital to recruit clients, or if clients return for future projects. While many clients did not receive a “successful” project, the majority did receive a positive return on their investment of time. In some cases, this was through the clarification process required to relay their questions to the students. In others, there was a partial success as students completed early steps in the solution generation process. And, as stated above, approximately

35% of the projects did achieve success. Based on personal communications between the instructor and clients, most clients left satisfied, and open to working on another project.

For transformative learning to take place, educators have to establish an environment in which several key conditions exist. To begin with, they must make sure those participating have complete information. They must understand power dynamics; it is important that all who participate in the dialogue are free from coercion and have an equal opportunity to advance, challenge, defend, and explain beliefs, assess evidence, and judge arguments. Individuals should be encouraged to examine their assumptions critically, as well as be open to other perspectives. Finally, those who participate should pledge to listen and work toward a synthesis of different views or find common ground. When these conditions exist, the work of examining failure and finding new ways of thinking and doing becomes easier (Mezirow, 1997). Thus, the three authors believe we were able to experience transformative learning precisely because we took time to talk about the power dynamics, especially those between the student and the adults (project manager and professor). Ultimately, the learning occurred because all stakeholders shared their thoughts, listened to others' perspectives, and together, crafted plans.

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