Does Experience with Collaborative Problem-Based Projects Alter Student's Tolerance for Ambiguity?

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Abstract

Many engineering and engineering technology programs require their seniors to take the capstone design courses to graduate. Also, the courses are required by accreditation bodies, like ABET and others, for those programs to be recognized. During the capstone design course, students are expected to apply everything they learned from the inception of their study. Students in the Aeronautical Engineering Technology program at Purdue University are no exception to this rule. They possess hands-on technical and engineering skills with aerospace vehicle systems; they are able to think critically and manage projects along with the foundation of a broad academic education. However, the students have difficulty adjusting or accepting the fact that their projects during the senior capstone design courses may change in the process, including the end goal and scope. The purpose of this paper is to examine if previous experience with collaborative problem-based "real life" projects alter students' tolerance for ambiguity.

Keywords: *Tolerance for Ambiguity, Problem-Based Learning, Senior Capstone Design Course*.

1. Introduction

Problem-based learning (PBL) is widely used in engineering programs across the world. Students work in teams, preferably multidisciplinary, on real-live complex problems. To mention some examples, PBL can be found in the undergraduate curriculum in Aeronautics and Astronautics at Massachusetts Institute of Technology, where a multitude of engineering courses, from freshman to senior offerings, is based on this approach. The students design, build, and test radio-controlled lighter-than-air vehicles as well as complex space systems [1]. All students at the Department of Civil Engineering and Construction at North Dakota State University are required to complete a departmental capstone course [2]. Ellis described two case studies on problem-based projects in computing [3]. In this case, structured lectures are replaced with open-ended problems, where multiple possible solutions exist. The role of the educator is changed: instead of a lecturer, he or she becomes a facilitator [4]. The students engage in reflections and this guides them to higher-order thinking [5]. However, PBL has its difficulties. For example, the seniors of the Department of Aviation Technology's Aeronautical Engineering Technology (AET) program struggle with sudden and unexpected changes in their capstone design projects. This often becomes a "stumbling block" in finishing a project. Thus the ability to tolerate ambiguity is one the most necessary skills in engineering in general. It is even considered to be an important requirement for an engineer [6], and if the student doesn't possess it, he or she is not prepared to successfully practice engineering.

2. Tolerance for Ambiguity and Research Design

Yurtsever describes tolerance for ambiguity as "the extent to which an individual feels threatened by an ambiguous situation" [7]. People with high tolerance for ambiguity are able to make decisions where a situation is not clearly defined. Tymula et al studied a link between adolescents and their risk behaviours [8]. The researchers found that increased risky behaviour was not driven by risk itself but a higher tolerance for unknown results (higher tolerance for ambiguity). The most known and used quantitative

instruments to measure tolerance for ambiguity are Walk A Scale, Budner's scale, Rydell's scale, and MacDonald [9]-[12].

The study was designed to identify and analyze possible effects of the design experience on tolerance for ambiguity. A series of standard instruments was used throughout two semesters to discover change or lack of it in the ability to tolerate uncertainty in design. The MacDonald's scale (1970) was deemed most appropriate for this purpose. To statistically analyze the data is still in the planned for the near future and results might generalize the senior design course. However, those results will lack the personal experiences of the students. To address this issue, a series of face-to-face interviews took place with the approval of the Institutional Review Board (IRB). Personal identifiers were removed for this study to protect the students' privacy.

3. Results and Discussion

Analysis of data collected is presented in Figure 1:

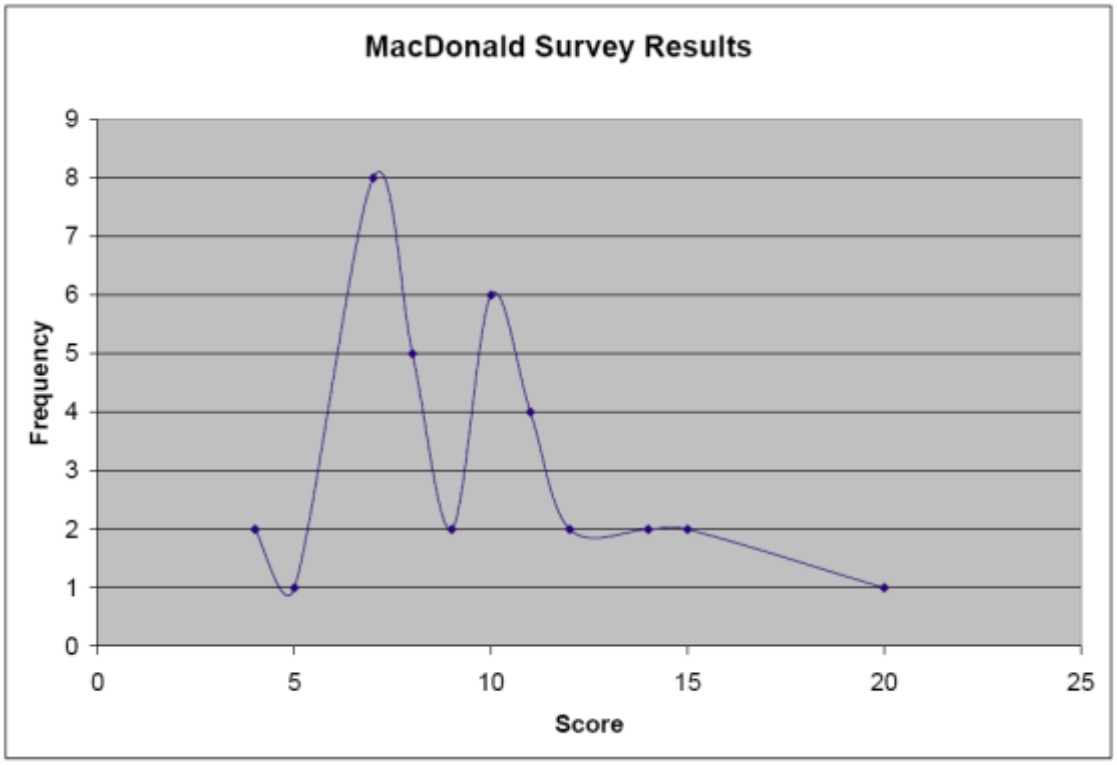

Figure 1. MacDonald Survey Score vs. Frequency.

As noted on the graph, there were two well-defined peaks present, the highest one at the 7 point mark and a smaller one at 10, with the maximum possible score being 20. One of the students with the most common score (7), who we will call "Sam", was interviewed, and results of this interview are presented below. It is also worth noting that he was a Reserve Officers' Training Corps (ROTC) cadet and will be serving in the military as an officer: "We'll be officers, we'll be in charge of a division right off the bat." At the beginning of the interview, Sam said that he was thinking of enrolling in the Purdue University College of Engineering but "did not get in." So he asked ROTC personnel for advice. They suggested the College of Technology (COT):

> "I looked into it, and it seemed more my thing just because it's more hands on, and I'm like, "I'm definitely going to reapply and try to go to that. And once getting into AET,

> and after I think it was the second semester of my freshman year, we actually got our hands dirty and greasy. I'm glad I didn't get engineering. This is where I belong."

The idea of "getting hands dirty and greasy" resurfaced multiple times during the conversation. He really liked "hands on" experiences. It also worth noting that Sam selected a highly ambitious and complex project offered with no available mature technical solution at this period of time. Projects and teams were not assigned by the instructor. The students had freedom to select their teammates and topics. His group was the first to get organized and they decided to "tackle" the hardest and most ambiguous task.

During the interview, Sam stated at least twice that he does not like change. However, every time he admitted that if a change happens, he is willing and able to adjust and "move forward":

> "In general, I don't like change. I mean in everyday life, something changes. I'm like, "Oh, now I've got to adjust." But you know, I do realize that if nothing ever changes, we're not going to get anywhere."

> "So as much as I don't like change, I have to adjust. I get settled on one thing, good routine, and then something changes. It's like all right. But that change is good. That's how we move forward, and with our project, we had to change our outcome. We're moving forward. Yeah. So how did we deal with these changes? Move forward."

The whole concept of "moving forward" was evident throughout the interview. The word *change* was used multiple times and it was almost always followed by phrases like, "let's give it a shot," "back up a step," "let's back that up even another step," "let's look at it again," "come up with new process" and so on. He always looked at possible, and feasible, solutions, and did not complain about his teammates, lack of time, etc. One line in his talk struck the author: "You've got to give and receive a little bit." For the researcher, it sounded like a good strategy to reduce complexity and to "move forward" to the end result, which was, according to the conversation, very important to Sam. He is an achievement-oriented person, who wants to see tangible results of his work and to be in control of a project:

> "…we had a desired outcome we wanted, but as to how we get there, how we get to that desired outcome is entirely up to us."

> "And although I loved [AT]308 [another, more structured course in the program], you know, being able to say this is what you're going to make, and going through and saying, 'I actually did this,' and then you're going to another one where you kind of get a better self-satisfaction of, 'All right, I'm going to make a rocket,' but I also came up with how I'm going to make that rocket. So it's kind of you get a double effect of self gratitude there."

> "We've got to move forward instead of just [doing] research after research. Let's start moving forward on it."

> "I think my experience is beginning to meet my expectations, which were to actually take an idea and then just crunching that idea and use a certain process and hopefully come with an end result."

Another big thing for Sam was the ability and desire to work with other students in the team environment. He talked at length about communication and its importance to achieve the end goal:

> "So many places where we could fail. You know, communication being the biggest one."

> "And a lot of it is group work, so there has to be communication skills, listening skills, working with being able to give and take on your ideas. Some things – you know, I really think it should be done this way, but everyone really thinks it should be done that way."

> "So like let's work with the other groups that are in the same project, and let's put something together."

Sam also mentioned the word *process* many times. Sometimes it meant a *learning process*, sometimes a *manufacturing or design process*. Even phrases *moving forward*, *backing up*, etc. have the flavour of components of a process, but in each case it required a desirable outcome. Also, Sam expected a process to morph over time and he anticipates this:

> "So we actually have to design our own process, and that process changes depending on new challenges that comes up."

> "I also did like [AT]308 because it helped us learn a process, set up a lathe, and then okay, so we turn the piece down."

> "We've got to make a process."

> "In a way, when change comes about, you kind of have to not completely start over, but go back to the beginning of all right, this is new. Gotta come up with a new process. If we're not – all right, the end result is different."

> "And I think my experience is beginning to meet my expectations, which we're able to actually take an idea and then just crunching that idea and use a certain process and hopefully come with an end result."

4. Conclusion

To sum everything up, Sam presented himself as an adaptive and open-to-change person, who also was achievement driven. This conclusion contradicted how he perceived himself as person who "does not like change." Based on this finding, the author of this paper discovered that any survey results, except big scale studies, ideally must be followed by series of qualitative methods such as face-to-face interviews to better understand phenomena and to reach right conclusion.

References

[1] D. Brodeur, P. W. Young and K.B. Blair, "Problem-Based Learning in Aerospace Engineering Education," *Proceedings of the American Society for Engineering Education Annual Conference and Exposition,* ASEE-2002, Montreal, Canada, 2002.

[2] C. McIntyre, "Problem-Based Learning as Applied to the Construction and Engineering Capstone Course at North Dakota State University," *Proceedings of the 2003 Frontiers in Education Conference, FIE-2003,* Boulder, CO, 2003.

[3] A. Ellis, L. Carswell, A Bernat, D. Deveaux, P. Frison, V. Meisalo, J. Meyer, U. Nulden, Rugelj and J. Tarhio, "Resources, Tools, And Techniques For Problem Based Learning In Computing," *Proceedings of ITICSE'98 Working Group on Problem Based Learning*, Dublin, Ireland, 1998.

[4] G. Maudsley, "Roles and Responsibilities of the Problem Based Learning Tutor in the Undergraduate Medical Curriculum," British Medical Journal, Vol. 318, No 7184, pp.657–661, 1999.

[5] C. E. Hmelo and M. Ferrari, "The Problem-Based Learning Tutorial – Cultivating Higher Order Thinking Skills," Journal for the Education of the Gifted, Vol. 20, No. 4, pp. 401–422, 1997.

[6] B. V. Koen, *Discussion of the Method: Conducting the Engineer's Approach to Problem Solving,* Oxford University Press, 2003, pp.7-25.

[7] G. Yurtsever, "Tolerance of Ambiguity, Information, and Negotiation," Psychological Reports, Vol. 89, pp. 57-64. 2001.

[8] A. Tymula, L. Delmaker, A. Roy, K. Manson, P. Glimcher and I. Levy, "Adolescents' Risk-Taking Behavior Is Driven By Tolerance To Ambiguity," Proceedings of the National Academy of Science, Vol. 1, No. 42, pp. 1735-1740, 2012.

[9] P. O'Connor, Ethnocentrism, "Intolerance of Ambiguity', and Abstract Reasoning Ability," Journal of Abnormal and Social Psychology, Vol. 47, pp. 526-530, 1952.

[10] J. Budner, "Tolerance of Ambiguity as a Personality Variable'" Journal of Personality, Vol 30, pp. 29-40, 1962.

[11] S. T. Rydell and E. Rosen, "Measurement and Some Correlates of Need Cognition," Psychological Reports, Vol. 19, pp. 139-165, 1966.

[12] A. P. MacDonald, "Revised Scale for Ambiguity Tolerance: Reliability and Validity," Psychological Reports, Vol. 26, pp. 791-798, 1970.

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