Mindset Changes in Aviation Technology Freshman and Senior Capstone Design Students

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Abstract

Student or practicing engineers' attitudes toward learning can affect their learning skills and their effectiveness in gaining new knowledge or developing professionally. This is the claim of Carol Dweck's 30+ years of research on mindset or attitudes toward intelligence and learning ability. Dweck's research establishes a continuum of an attitude toward learning between a fixed mindset-you can't change how smart you are-and a growth mindset-failure is a chance to learn. This paper presents our findings about the effect on mindset of a year-long design experience for seniors in an Aviation Technology Design course compared to freshmen in a semester long Introduction to Aviation Technology course. Our findings did not show a significant statistical change in mindset for our senior Aviation Technology students or significant statistical differences in mindset changes between the Aviation Technology students in the senior design course and our freshmen technology students in the Introduction to Aviation Technology course. However our data shows that significant changes in mindset had occurred for our freshman compared to seniors during their 4-5 years of Aviation Technology studies.

Keywords: *Mindset, Fixed, Growth.*

1. Introduction

The authors have taught senior design and freshman introductory courses for many years and were aware of the challenges of structuring a good open ended project that exposes the senior student to a typical engineering problem and engages them enthusiastically in a team based problem solving process. We also were aware of the need in designing capstone projects to respect the severe constraints imposed on our senior students by a full academic load, job search and graduation pressures. Each of the authors also has extensive industry experience and shared a common belief that continuing to learn is the only route to success as a Technology professional. These concerns led us to consider what our students believed about the need to continue to learn and how we might influence their beliefs about learning. Dweck appeared to have addressed these same concerns about an attitude toward learning albeit not in college technology students. [1]-[4]

These considerations led us to propose two research questions:

1. What differences in mindset exist between our freshmen and senior Aviation Technology students?
2. Do our Aviation Technology students exhibit any changes in mindset as a result of taking our freshman introductory course or our senior capstone design course?

This paper is organized as a discussion of the purpose of senior capstone courses, the concept of mindset, a description of our samples, the research methodology, and the findings, conclusions and next steps.

2. The purpose and effectiveness of senior design courses

Senior capstone design courses have been popular for the past 2 decades or more. These courses are intended to mimic the real world and the commonly held belief is that they help prepare students for the real world open-ended projects which they are about to face in their new jobs. In a survey of capstone design courses published nearly 20 years ago, Duston et al described capstone design courses as learning experiences intended to emulate the contexts, challenges and design goals that students face in their jobs after graduation.

> "Educators from all engineering disciplines have developed courses built around open-ended design projects similar to those found in industry. Although the individual structures of capstone design courses are extremely diverse, the objective of nearly all such courses is to provide students with a real-life engineering design experience. Other objectives often include the development of interpersonal and communication skills, enhancement of student confidence, and improved university relationships with industry". [5]

However whether student capstone design projects actually support learning of practical 'real world' methods or emulate real world problems is questionable according to researchers [6]. Miller et al pointed out that students in senior design projects don't even use design tools or methods they believe work because of the pressure of getting their projects done (and probably graduating).

> "Results from a survey of [capstone design students] suggest that, though these novice engineers were convinced that design methods they were eager to learn were of use in helping them make better products, they tended not to use them. The stated reasons for not using them were the effort required to implement the methods, to understand how and when to use the methods, and the pressure to deliver results in a short duration". [6]

While we accepted that the goal of capstone design courses of preparing students for their 'real world job' is appropriate, we concluded that affecting their attitude toward learning was potentially more critical to success in their professional journeys. Today corporations are evaluating the learning attitudes of their science and engineering hires.

> "In today's challenging business environment it is not enough to have an essential skill-set because the skills needed to remain competitive change so rapidly. Therefore, when recruiting employees it is important to evaluate candidates for their aptitude for learning as well as for their current knowledge and skills.". [7]

Numerous articles and authors point to the rapidly changing knowledge base of science and engineering and the need for continuous learning by those who practice in these professions. [8]

> "The durability of knowledge in the fields of science and engineering is much shorter than in other academic fields. Therefore, scientists and engineers need to update their human capital at a regular basis in order to prevent skills obsolescence." [8]

We also concluded that focusing on non-cognitive characteristic of our students-e.g. mindset- may have a more long term impact on their future success that any specific skills or knowledge they might gain through our courses [9, 10]. This conclusion led us to explore several non-cognitive measures like self-efficacy and mindset and to begin to measure the mindsets and mindset changes of different groups of our Aviation Technology students.

3. Fixed vs. Growth Mindset

A fixed mindset means that the individual believes that the intelligence they possess is all they will ever possess and cannot be changed. Students with a fixed mindset believe that making a mistake means they lack ability; if they had the ability and intelligence, they should be able to succeed. [4] [11]

Students with a growth mindset believe that intellectual ability is can be affected by education; thus individuals have a chance to increase their intelligence by learning more. These students are more likely to believe that it is more important to learn in a class than to receive a specific grade. [4] [11]

Sarah Miller Caldicott points out that "when learning goals dominate an environment, people are motivated to develop the attribute that they learn", or what we believe is an essential mindset of the life-long learner, continuously growing their knowledge and skills [12] [13]. Our conclusion was that influencing a student's mindset as defined by Dweck will affect their attitude toward learning and strengthen their ability to build their competency as a technology professional.

4. Aviation Technology Courses and Students in the Experiment

197 unique students were tested in two different courses in three courses in our research: There were 73 students in the pretest and 127 students in the posttest in the fall 2012 Gateway to Aviation Technology course, a freshman course and our control sample. There were 70 students in the fall 2012 sections of Applied Research Project (in Aviation Technology), a senior capstone design course. There were 50 students in the 2013 spring sections of Applied Research Project (in Aviation Technology). There was no design experience in the freshman Gateway to Aviation Technology course while the Applied Research Project course was heavily focused on learning and using problem solving and design processes. The control sample was chosen because of the lack of a design experience in that freshman class and the fact that one research question was to examine the mindset differences between freshmen and senior Aviation Technology students.

Gateway to Aviation Technology provided an overview of the aviation industry, an introduction to the Department of Aviation Technology, and perspectives of the different career paths that are potentially available for prospective graduates. Course topics included basic aircraft science, aircraft nomenclature, theory of flight, the regulatory process, and aviation regulations. Aviation safety practices and human factors issues were discussed as well as information needed to operate as a private pilot in the aviation environment. As part of this course, every student gained flight experience in a university aircraft. Students in the course are typically a mixture of from a variety of disciplines across the university but a majority of the students in this course were part of the Aviation Technology Department and were pursuing degrees in Professional Flight, Aviation Management, or Aeronautical Engineering Technology. The course is considered a "flipped" or "upside down" course with the basic lecture material being accessed online and in class interactions designed for higher levels of learning on Bloom's Taxonomy. The online material is focused on the material necessary to be successful as a private pilot and there are in-class collaborative modules for Aviation Management and Aeronautical Engineering Technology students.

Applied Research Project (in Aviation Technology) was a senior capstone design course, which included all components of the Aeronautical Engineering Technology program. Students worked hands-on in collaboration with industry and Purdue University researchers. Using Six Sigma methodology, the students analyzed needs and existing problems, found conceptual alternatives, selected the best fit solutions, designed components and assemblies, and manufactured final products. In some cases, students worked on existing products, processes, and services to improve them. Beside technical and design skills, students learned team dynamics and the importance of communication and project planning.

5. Research Methodology

Dweck's mindset instrument is a 27-item survey designed to assess fixed vs. growth mindset. Exploratory factor analysis in each of the sections of both courses (and for both freshman and seniors) confirmed two distinct constructs in every section composed of exactly the items that Dweck labeled as

measuring either fixed or growth mindset. These results are consistent with validation of the Dweck instrument in K-12 students.
Dweck's instrument was administered in the first two weeks [pretest] and the last 2 weeks [posttest] in the one semester freshman Introduction to Aviation technology course in fall 2012. In the one year Aviation Technology Capstone Design class Dweck's instrument was administered in the first two weeks of the first semester [pretest] and in the last 2 weeks of the 2nd semester [posttest]. The survey was conducted as a voluntary and anonymous student activity per IRB approvals although some class time was made available to complete the survey in all three course offerings and in both semesters.

Comparisons of the data were made in pre and post test cases for both the control sample [freshman students] and for the capstone design sample and between freshman and seniors for the pre and post samples. Statistical significance was determined using a Mann-Whitney nonparametric test of comparison, using SAS (Version 9), *proc npar1way* with *wilcoxon* option. Nonparametric tests were selected to avoid a required assumption of data normality. Statistical significance of differences is influenced by sample size, and a statistically significant difference does not *necessarily* imply a meaningful or important difference – only that a true difference most likely exists. The effect size, or Cohen's *d*, is a measure of the magnitude of the effect or the importance of the difference. Cohen's d is found by:

$$d = \frac{(M_1 - M_2)}{\sigma_{pooled}} \qquad (1)$$

where M1 and M2 are the means of the population. The pooled standard deviation, σ_{pooled}, is the root-mean-square of the standard deviations of the two populations [12]. That is, the pooled standard deviation is:

$$\sigma_{pooled} = \sqrt{\frac{{\sigma_1}^2 + {\sigma_2}^2}{2}} \qquad (2)$$

When the two standard deviations are similar (as is typically the case), the root mean square differs very little from the simple average of the two variances.

While Cohen originally defined ranges for effect sizes as small: $d = 0.2$, medium, $d = 0.5$; and large, $d = 0.8$, the suggested ranges of effect size were adjusted for different applications shortly after publication of these initial estimates. Hyde defined the ranges as part of the Gender Similarity Hypothesis as: near-zero, $d \leq 0.10$; small, $0.11 < d \leq 0.35$; moderate, $0.36 < d \leq 0.65$; large, $0.66 < d \leq 1.0$; and very large, $d > 1.0$; based on subsequent exploration of effect sizes as they apply to research in the social sciences.

6. Findings

The average data collected from the 4 administrations of the mindset survey are shown in Table 1 below. Fixed mindset is measured by taking the average of 15 survey items and growth mindset scores are computed from the average of 12 survey items.

Table 1. Mindset survey means and pre-to-post-test differences.

Mindset	Pretest-Fixed Mean	Posttest-Fixed Mean	d, pre/post effect size	Change pre-post	Pretest-Growth Mean	Posttest-Growth Mean	d, pre/post effect size	Change pre-post
Freshman control fall 2012	**2.7**	**2.78**	**0.1126 small**	**0.08**	**3.54**	**3.44**	**0.1530 small**	**-0.1**
Number of students fall 2012	73	127			73	127		
Seniors-design experience	**2.52**	**2.5**		**-0.02**	**3.56**	**3.46**		**-0.1**
Number of students	Fall 2012-70	Spring 2013 -50			Fall 2012-70	Spring 2013 -50		

The changes observed in our control sample were expected, a tendency toward a more fixed mindset with a small effect size (d= 0.113) as freshman coped with the rigors of college tests, potentially more challenging material and increased competition. This movement toward becoming more fixed in mindset is also consistent with the slight diminishing of their growth mindset again with a small effect size (d=0.153). However, the lack of evidence of any significant change to a more growth oriented mindset in our senior capstone design students was a disappointment. The lack of any significant observed improvement in the growth orientation of our seniors after a whole year of supervised teamwork and design experiences and the slight inclination away from a growth mindset was discouraging and these changes or lack thereof are illustrated below in Figures 1 and 2.

Figures 1 and 2 display the changes in the fixed and growth mindsets for the pre and post comparisons of the freshmen in the Introduction to Aviation Technology course and the seniors in the Aviation Technology capstone design course. Figure 3 displays the difference between freshmen and seniors in their fixed mindsets.

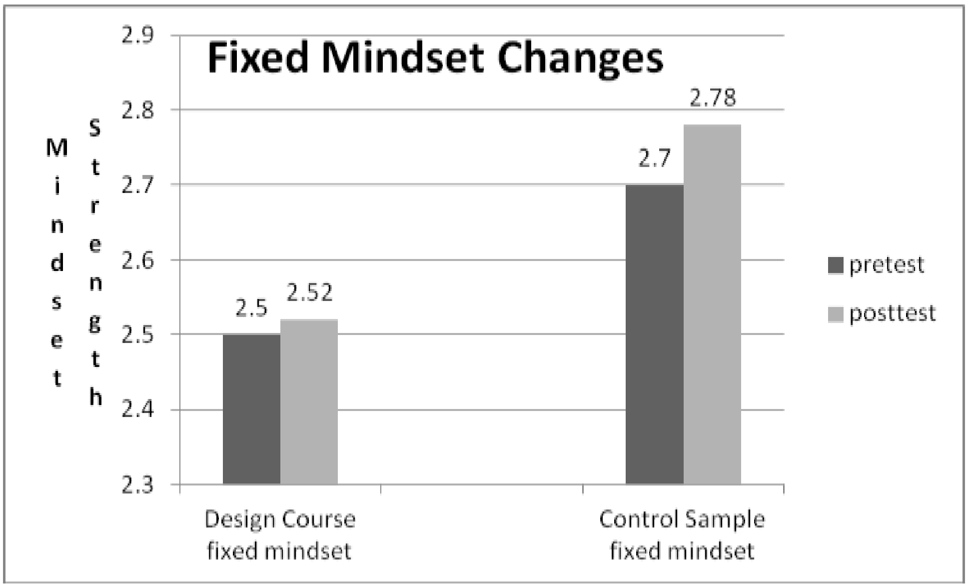

Figure 1. Comparison of changes in Fixed Mindset.

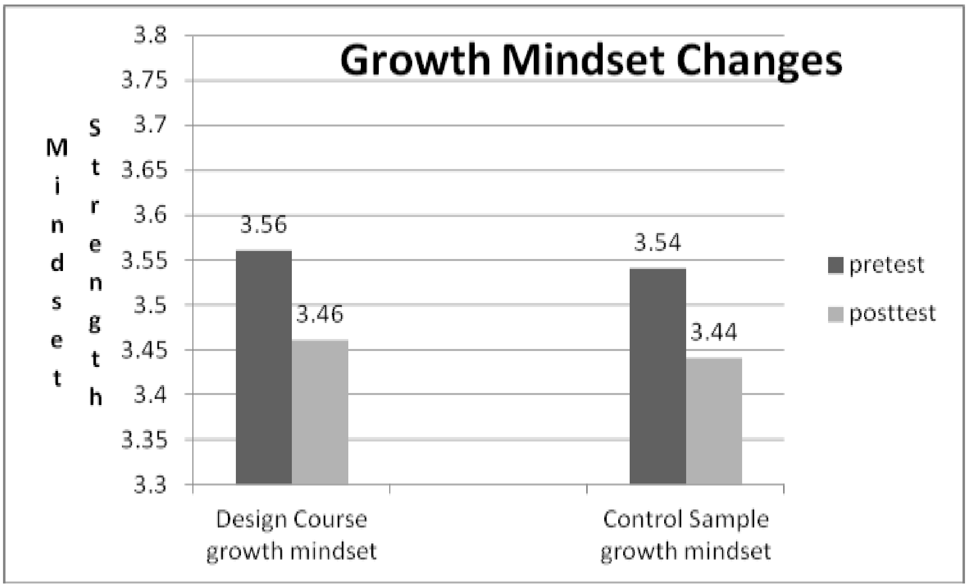

Figure 2. Comparison of Changes in Growth Mindset.

Table 2 Mindset Comparisons of Freshman and Seniors in Aviation Technology

Mindset	Pretest-Fixed Mean	Posttest-Fixed Mean	d, pre/post effect size	Change pre-post	Pretest-Growth Mean	Posttest-Growth Mean	d, pre/post effect size	Change pre-post
Freshman control fall 2012	**2.7**	**2.78**	**0.1126 small**	**0.08**	**3.54**	**3.44**	**0.1530 small**	**-0.1**
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Figure 3. Fixed mindset comparisons of freshmen and senior Aviation Technology students.

The gap in fixed mindset shown in Table 2 and Figure 3 is the most positive result of our experiment. While we can't explain how or why our seniors have less of a fixed mindset than our freshmen, this observation suggests that the courses or experiences of senior students during their previous 4-5 years had a significant effect on their attitude towards learning.

7. Conclusions

We did not find a significant difference in the change in mindset during the freshmen year as compared to the senior year of study for students in the capstone design course in Aviation Technology. We did find however that our seniors tested as having a less fixed mindset than our freshmen. We also observed a tendency with a small effect size for our freshmen to move toward a more fixed and less growth mindset.

8. Next Steps

Testing mindset levels for our Aviation Technology students at more points during their course of study or before or after other courses or other learning experiences which may impact mindset will help us identify those curricular or extra-curricular experiences which contribute to the observed change in fixed mindset of our senior students compared to our freshman students. Repeating our experiment and comparing other College of Technology majors mindset changes will help us confirm our findings.

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