



## **Improving engineering student preparedness, persistence, and diversity through conative understanding**

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# **Improving engineering student persistence and diversity through conative understanding**

## **Abstract**

Engineering teaching strategies that engage students are desperately needed to recruit, retain, and prepare students in science, technology, engineering and mathematics (STEM) fields to address challenges facing the 21<sup>st</sup> Century. This paper describes a method for integrating behavioral instinct learning modules into freshman engineering classes. The method includes an online instinct assessment, in-class activities created to illustrate instinctive behavior related to engineering tasks, practicing awareness through class projects, and reflective writing to encourage students to critically think about this awareness for future classes, activities, and careers. The effectiveness of the methods described herein will be evaluated through the use of surveys, reflective essays, and interviews with faculty and students. The assessments have not yet been completed; we are in the midst of collecting data for the semester. Our initial results show that conative understanding increases satisfaction and confidence, which we hypothesize will lead to improved retention. This paper summarizes the conative interventions in engineering, the research methods, and preliminary results.

## **Introduction**

In engineering advanced cognitive skills are highly valued and consistently rewarded. However, the mind consists of three separate domains: cognitive, affective and conative (Hilgard 1980 and Tallon 1997). By focusing only on one of the three, students who don't fit the typical mold may feel marginalized and discouraged from completing an engineering degree. We suspect that by exploring this idea we may discover an avenue to increasing retention and diversity in engineering.

The three parts of the mind govern what we think, how we feel about it, and how we instinctively respond to situations. The cognitive domain houses learned information, a person's knowledge and skills. The affective domain houses emotional responses to this learned information, and determines such things as personality, values, and motivation. The conative domain houses striving instincts and describes how people most naturally approach challenging situations.

This paper explores the relationship between conative awareness and retention in engineering. Institutions across the United States experience major problems retaining students, citing contribution factors to include a lack of appropriate funding and support services, lack of innovative instruction, and lacking collaborative learning environments (Lau 2003). Engineering typically loses 40% of students after the first year; while the percentage of women in undergraduate engineering programs rarely tops 20% (with the exception of bioengineering, estimated from enrollment and degrees awarded from National Science Foundation National Center for Education Statistics (Chen 2009). According to the President's Council of Advisors on STEM, in order to increase diversity and retention of women and minorities in STEM fields, educators must better engage students in their education and give all students the tools to excel (PCAST 2012). Conative awareness focuses on students' strengths as opposed to weaknesses or differences. This awareness helps create an environment of student centered learning; by

understanding innate problem solving skills students can perform more effectively by working in harmony with their talents rather than against them. This information can be especially impactful in retention of women and underrepresented students whose retention is already at risk because perceived lack of academic competence, loss of self-confidence, and few instructors that can be seen as gender and diversity role models (Brainard & Carlin 1997). Introducing the concept of conation at the freshman level is intended to assist students with forming strong relationships, building confidence, and enhancing understanding of individual strengths to enable them to persist and succeed in engineering programs.

This study analyzes the effectiveness of teaching conative awareness to students in first year engineering classes. Specifically, this paper describes a method for integrating conation into freshman introductory engineering classes at a community college: Chandler Gilbert Community College in Arizona. The method includes an online conative assessment, in-class activities created to illustrate conative behavior related to engineering tasks, practicing conative awareness through class projects, and reflective writing to encourage students to critically think about conative awareness for future classes, activities, and careers. The effectiveness of the methods described herein were evaluated through the use of interviews with faculty. A survey to assess student perception towards the impact of conation on persistence in an engineering program has been developed and will be implemented during the spring 2015 semester, these results are not yet available. The survey is included in this paper within the Future Work section.

Our hypothesis is that students will perform better and be more likely to stay in engineering programs after learning more about themselves through experiences in conation.

## **Methods**

The conation and teamwork module was integrated into seven freshman-level introduction to engineering courses taught by the same engineering instructor at the same community college. The first four courses occurred during the fall 2014 semester and provided significant anecdotal evidence suggesting additional benefits beyond good teamwork instruction. The additional three courses are in progress, spring 2015 courses, from which survey data will be collected.

The course is a 2-credit course that guides students through the engineering design process and introduces them to common engineering tools and software. The majority (about  $\frac{3}{4}$ ) of the term is spent working on a variety of team projects. The conation and teamwork module is delivered the first four weeks of class to prepare students for successful teamwork interactions for the remainder of the term. The module is described below and summarized in Figure 1.

### ***Week 1***

The semester begins with a teamwork icebreaker activity on Day 1; students reflect on the best team they've ever been a part of and share with the class why it was such a good team. During the discussion good teamwork characteristics are added to the white board. This activity sets the tone for the teamwork expectations for the coming term. After the icebreaker activity the instructor introduces students to new topics through the National Academy of Engineering Grand Challenges. It is then revealed to the students that they will be tasked with working in teams to research one of the challenges and prepare a 10-minute presentation for the class. Students are

assigned a short reading homework assignment on good teamwork characteristics. On Day 2 students are introduced to the concept of conation and the three parts of the mind, led through a lecture and class discussion on teamwork. Students are assigned an online conation assessment for homework.

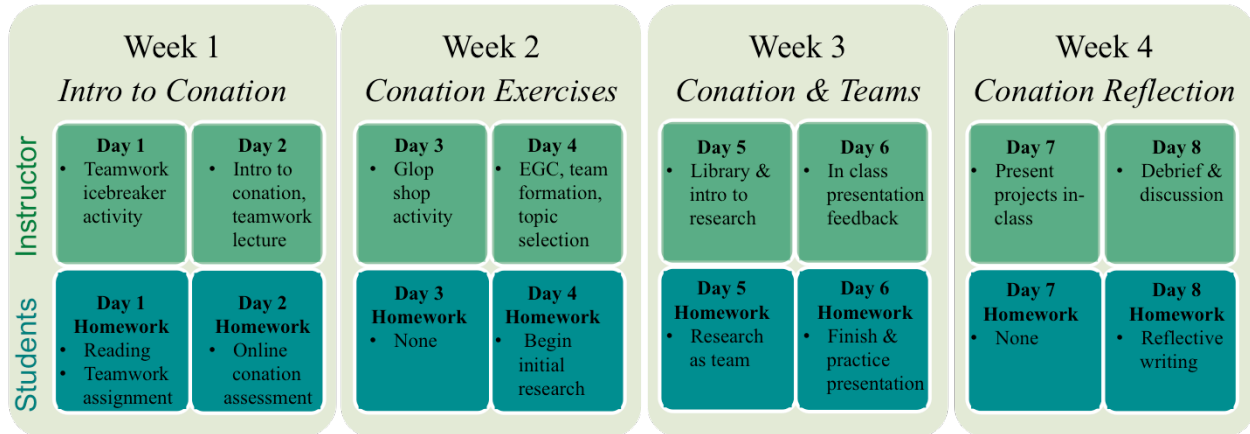


Figure 1. Summary of 4-week conation teamwork module used in freshman introduction to engineering courses.

***What does the conation assessment evaluate?***

Conative profiles are assessed using the Kolbe A™, a 36-question online tool that takes approximately 20 minutes to complete. Results are reported along four Action Modes® (Kolbe, 2003):

- **Fact Finder – instinct to probe**
- **Follow Thru – instinct to organize**
- **Quick Start – instinct to improvise**
- **Implementor – instinct to construct**

Each action mode spans a continuum of conative strengths from resistance to insistence (Figure 2). Resistance indicates the tendency for the individual is to prevent problems in this mode, whereas insistence is the tendency to solve problems in this way. Accommodation indicates that a person is naturally inclined to accommodate either style of problem solving, resisting when necessary and insisting when necessary (Kolbe, 2013). The continuum for each mode spans from a value of 1 to 10; 1-3 indicates resistance, 4-6 accommodation, and 7-10 insistence.

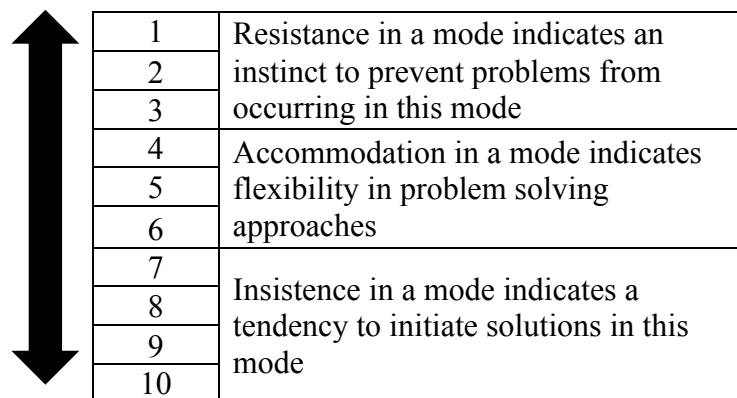


Figure 2. Kolbe A continuum.

The Kolbe A results are reported along the four Action Modes providing a single value within each, identifying four unique conative strengths. The most insistent action mode in an individual's Kolbe A profile identifies how a person starts the problem-solving process when striving.

For example, an initiating Fact Finder (FF) is likely to perform best when required to:

Probe	Allocate	Define	Calculate
Research	Deliberate	Prove	Inquire
Formalize	Prioritize	Specify	Evaluate

Whereas, an initiating Follow Thru (FT) is likely to perform best when required to:

Structure	Prepare	Arrange	Plan
Consolidate	Discipline	Integrate	Budget
Translate	Coordinate	Schedule	Chart

An initiating Quick Start (QS) is likely to perform best when required to:

Invent	Devise	Risk	Improvise
Brainstorm	Challenge	Play hunches	Promote
Originate	Contrive	Reform	Intuit

And an initiating Implementor (IM) is likely to perform best when required to (Kolbe, 2003):

Form	Craft	Build	Fix
Mold	Shape	Render	Repair
Demonstrate	Put together	Construct	Practice

(Kolbe 2003)

### ***Week 2***

After completing the Kolbe A Day 3 of class is allotted to in-class interpretations and conative behavioral teaming activities (Adams et al 2014). This gives students the opportunity to put their own strengths into practice and to observe the differences between their strengths and those of their classmates.

Project teams are built based on the conative profile knowledge on Day 4. Building teams in this manner allows for students to build teams with the broadest spectrum of strengths and it puts their expectations of each other into perspective. Focusing on known strengths minimizes unreasonable expectations.

### ***Weeks 3 and 4***

Days 5 and 6 are reserved for research time in the library and practice presentations with feedback, respectively. Students present their team research project on Day 7. After presentations students reflect on a) the content and how this experience has impacted their views on engineering, b) the mechanics of giving a good presentation, and c) on teamwork by completing a reflective writing assignment considering how they interacted as team members. Feedback from these reflections is used to evaluate the effectiveness of the module.

## Results and Discussion

From an instructor's perspective the module has been hugely successful. Inclusion of conation has increased overall satisfaction with teamwork experiences, thereby creating positive experiences for students as they are introduced to engineering (Adams et al 2014).

The module is a great way to start the semester. Discussion of each student's innate strengths and how they utilize them during the second week of classes allows students to get to know each other right away. By focusing on strengths students begin to see how differently each of us operates and to appreciate those differences. This kind of empathy while working together on teams can be a valuable tool for overcoming, and even avoiding, conflict.

Additionally, students have reported through peer evaluations and in reflective writing assignments that the experience has been positive. They've noted such things as:

- an increased ability to identify and utilize individual strengths
- that conative awareness helped them to set up roles that worked for everyone and took advantage of these strengths
- that taking the time to discuss individual strengths at the beginning of the project helped to establish reasonable expectations of one another

One of the key tenants of this module is to focus solely on *strengths* and to avoid talk of weaknesses, increasing the likelihood of empathy and patience with team members. Students acknowledged that perfect teams are rare and that things can still get done well despite this. They learned to be more patient with team members and to stay focused on the goal.

Teaching students conative understanding can be a way to intervene with students who have a fixed mindset to enable them to transition to a growth mindset. Research shows that students with fixed mindsets think that intelligence is inherent and unchangeable, thus they exert less effort to succeed (Hochanadel et al. 2015). The growth mindset is less rigid with respect to failure being absolute; in the growth mindset students recognize that the brain is capable of change. Research shows that students who demonstrate grit and a growth mindset are more likely to persist in their degrees and that cognitive intelligence is not the sole measure for predicting retention and success. A student with the growth mindset shows perseverance and passion for long-term goals. While conative awareness does not focus on goals; it does aid students in managing challenging situations and focuses not on cognitive or intelligence strengths but on natural strengths.

Figure 3 illustrates the breakdown of insistent conative strengths in the three spring 2015 courses and shows a summary of the three classes combined. Recall that the most insistent action mode in an individual's Kolbe A profile identifies how a person starts the problem-solving process.

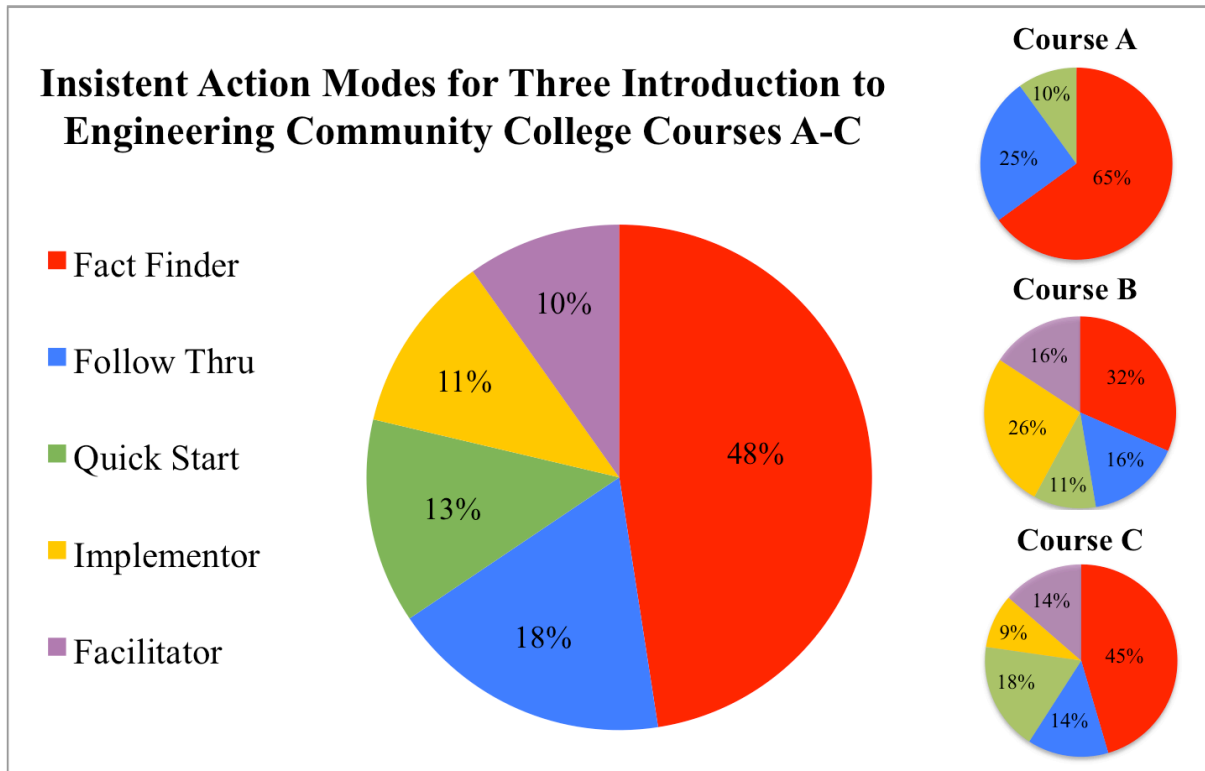


Figure 3. Insistent behavioral traits of freshman engineering students in three separate introduction to engineering courses (spring 2015). Note that “Facilitator” describes a Kolbe A conative profile in which there are no insistent Action Modes.

The majority of engineering students exhibit a primary insistence in the Fact Finder Action Mode. This indicates a tendency to do thorough research as a first step in problem solving. It has been the instructor’s experience that students with this conative trait often gravitate towards engineering, as they are “good students” as engineering has traditionally defined them. A similar survey of engineering students at the junior or senior level would show much less diversity in conative strengths than seen in Figure 3, primarily because the engineering curriculum is designed for students who are insistent fact finder.

It is interesting to note the differences between the three courses. Course A exhibits a large majority of Fact Finder and Follow Thru; 90% of the class falls into one of these two Action Modes, whereas Course B has a much more diverse conative strength distribution including the presence of some “Facilitator” students. These are students whose problem solving instincts are to balance team dynamics, they do not insist in any Action Mode and thereby make ideal team members by bridging gaps and preventing conflict.

In Course A teamwork experiences and best practices were more focused on how to overcome challenges on a team that are a result of everyone on the team wanting to take on the same role. In Course B diverse teams were easy to arrange resulting in more natural team role and project task assignments. All students were encouraged to take advantage of everyone’s individual strengths on the team. Teams with multiple insistent Fact Finders were given guideline and suggestions to help them from getting caught up in a “paralysis by analysis” situation.

Several of the team presentations given by Course B included demonstration models and example materials in addition to their PowerPoint slides, whereas only one team from Course A did. The team from Course A that did include a demonstration model was indeed the team with a member 10% outside of the typical engineering student mold. This student has a FF of 2 a FT of 3 a QS of 8 and an IM of 8. To motivate the student the instructor encouraged brainstorming and construction of a model – the student eagerly researched water filters and on presentation day had a slow sand filter built for the presentation that filtered muddy water to clear within the 10-minute presentation time limit. Peer evaluations showed that all team members were appreciative of the contribution and that this team member.

The courses have two additional teamwork projects before the end of the semester. The retention survey described in the following section will be given at the end of the term.

### **Future work**

Data collected thus far has focused on team satisfaction. Studies relating conative factors to student satisfaction and retention in STEM fields are few; however, results are positive and encourage additional work in this area. For example, Paimin et al. (2011) performed a study examining cognitive, affective and conative factors in persistence and found that learning intention (a conative measure) was crucially influential in students' levels of persistence in engineering, and affirmed the importance of identifying these intentions and fostering the link between intention and motivation for individual students (Paimin et al. 2011). Further, Lingard, Berry et al. (2005) provide evidence of students with certain conative strengths either preferentially self-select for engineering programs, or are more likely to persist in those programs. This suggests that students with alternative strengths may be discouraged somewhere along the way from pursuing engineering degrees (Lingard et al. 2005).

The next step in this work is to develop retention tracking instruments to evaluate how conative understanding impacts persistence and diversity in engineering. We will work with the college to track students' persistence, but in the meantime we will estimate students' intent to remain in engineering majors through reflective essays and surveys. Students will be provided multiple-choice responses for each survey question. The responses have not yet been collected. The survey questions related to conation include:

1. Have your experiences in **ECE 102** changed your plans to stay in this major?
  - a. [If Yes] How have your experiences changed your plans to stay in your major?
2. Have your experiences with **conation** changed your plans to stay in this major?
  - a. [If Yes] How have your experiences changed your plans to stay in your major?

While reflective essay prompts related to conation include:

1. List the conative profile for yourself and each team member, according to your Kolbe A results.
2. Describe how your team worked together.
3. What factors made your teamwork effective? What factors challenged the teamwork?
4. Discuss how you might modify your teams' activities or roles using conation.



Our hypothesis is that incorporation of conation into the curriculum will improve retention and persistence of diversity in conative strengths, which extends to diversity in other areas and addresses the need to improve success in educating underrepresented groups in science and engineering, including women and minorities (Marburger 2004). Conative awareness can also give students an explicit skillset that encourages a growth mindset, which has been shown to improve student persistence (Hochanadel et al. 2015). Awareness of conation may also foster learning communities and help students begin to create “personal visions of the future” by seeing themselves as an engineer with a diverse instinctive skill set (Huffman 2003; Vescio 2008). Conative awareness and the conation activities may enhance learning communities, perhaps by improving students’ understanding of one another and helping to build stronger relationships (Zhao 2004). Throughout the coming years, we will integrate retention data collected from the college with an analysis of the survey and reflective essays to evaluate our hypotheses.

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