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## **AC 2012-3356: MOTIVATING LEARNERS: A PRIMER FOR ENGINEERING TEACHING ASSISTANTS**

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# Motivating Learners: A Primer for Engineering Teaching Assistants

## Abstract

Although motivation in the classroom is often neglected in graduate student training, most instructors and TAs intuitively understand that motivation is critical for effective learning. These intuitions are corroborated by the research on motivation and learning that consistently shows that students do not learn well unless they are motivated to learn.

In this paper, we present the basics of motivation theories, their impact on student learning and their implications for teaching engineering. It is a primer of motivation theories and how they can be used to inform and direct TAs work with engineering students. This primer was developed from the perspectives of a researcher of the preparation of future faculty and a developer of teaching assistant training programs.

## 1 Introduction

In engineering education, motivation is often discussed from a programmatic perspective (how do we motivate students to enroll in engineering programs?) or a curricular perspective (how do we motivate students to persist?). These perspectives often overlook the importance of motivation within the classroom and the daily processes of teaching and learning engineering. Motivation helps students focus their attention on learning activities, proactively seek new learning activities, and persist in those activities until learning goals are reached<sup>1</sup>.

Although future engineering professors and instructors have a sense of the centrality of motivation in learning engineering<sup>2</sup>, they are often uncertain how to adjust their instruction to motivate their students. Many instructors who design new laboratory-based and project-based instruction to boost motivation find that these efforts are often greeted by apathy or resistance from the students. This situation is further exacerbated by curriculum (re)design efforts which emphasize the presentation and transmission of course material rather than everyday teaching decisions that motivate, or demotivate, the students to learn the material<sup>3</sup>.

Based on the premise that educational psychology must inform the practice of teaching<sup>4</sup>, this primer first presents and synthesizes a selection of recent theories of motivation. With these theories as a backdrop, we discuss how these theories can be used in and outside the classroom.

The Appendix is a table that summarizes the suggested teaching strategies and the motivation theories that support each strategy. The strategies were determined through a process of reflection and discussion amongst the authors about common engineering TA responsibilities. We also reflected on how motivational theories can help TAs understand the reasons behind and the power of common teaching advice.

Because previous work on motivation theories in the classroom has focused on the actions of faculty, this primer will particularly emphasize how engineering teaching assistants can promote motivation within the context of typical teaching assistant duties: organizing a discussion section, interacting with students in class and in office hours, grading of and feedback on student work, instructing laboratories, and creating homework assignments.

## 2 Review of Motivation Theories

### 2.1 Goal theory

Goal theory tries to explain why students engage in their academic tasks by describing the types of goals that students set and how they pursue those goals. Goals can be described by two parameters: orientation (mastery versus performance) and state (approach versus avoidance)<sup>5</sup>.

- *Mastery orientation goals* “orient the individual to focus on the task in terms of mastering or learning how to do the task.”<sup>6</sup>
- *Performance orientation goals* “orient the individual to focus on the self, ability, or performance relative to others.”<sup>7</sup>

Mastery orientation goals are more likely to guide students to deeper learning than performance goals<sup>8</sup>. Perhaps more important than performance/mastery orientation, students will pursue goals with an avoidance or approach state<sup>9</sup>.

- In *approach* state, behavior is directed towards a desirable event.
- In *avoidance* state, behavior is against an undesirable event.

By combining these states with the previous two orientations, we can create four compound orientations: avoidance-performance, avoidance-mastery, approach-performance, and approach-mastery<sup>10</sup>. Examples of each of these compound orientations are presented in Table 1.

Table 1: Examples of approach/avoidance - mastery/performance orientations:

	Performance	Mastery
Avoidance	“I don’t want to fail this class”	“I don’t want to look or feel stupid”
Approach	“I want to get an A”	“I want to understand this material, so that I can...”

The order of the compound orientations approximates how much each orientation supports learning from least to greatest. It is always better to approach a goal rather than avoid a goal and it is better to strive for mastery. In other words, teachers should always aim to dangle a carrot to pursue rather than threaten with a whip.

### 2.2 Attribution Theory

Attribution theory emphasizes that a person’s motivation increases or decreases proportionally to his or her expectation of achieving a goal<sup>11</sup>. For example, if a person believes he will fail at a given task, he will not undertake that task. This theory also proposes that motivation is moderated by a person’s explanations for why things happen to her. The interpreted causes for success or failure become the basis of that person’s motivation for future actions. Causes of success and failure can be characterized by three dimensions: *locus of control*, *stability*, and *controllability*.

1. *locus of control* - People believe that successes or failures are caused by factors within themselves (internal causes) or by factors in their environment (external causes). Prior research indicates this can be an issue for engineering students. Female students are more likely to incorrectly attribute success to luck (external) than their male peers who tend to attribute success to their abilities (internal)<sup>12 13 14</sup>.
2. *stability* - People believe that successes or failures are caused by factors that stay the same (stable) or change over time (unstable). For example, if a person thinks that her chance for success can be increased by increasing her effort (unstable), she may become more motivated. Note that unstable situations can increase motivation, because change is possible and potentially beneficial.
3. *controllability* - People believe that successes or failures are caused by something they can control (controllable) or cannot control (uncontrollable). For example, if a student thinks that he will get a bad grade because his teacher irrationally dislikes him, he will become demotivated.

Students commonly attribute success or failure to luck, task difficulty, ability, or effort<sup>15</sup>. Let us examine each of these individually in light of the types of attributions just discussed.

- *Luck* is an external, unstable and uncontrollable cause of success or failure. If a student attributes failure to bad luck, it is unlikely that the student will try to improve his or her performance through harder work because the cause is out of the person's control and is unlikely to change over time.
- *Task difficulty* is an external, stable, and uncontrollable cause for success or failure. If a student attributes an academic failure to the task being too difficult, the person might feel there is not much he or she can do to succeed in this task.
- *Ability* is often an internal, stable, and uncontrollable cause for success or failure. Consequently, if a student attributes an academic failure to a lack of ability, the student may not think that his or her actions can change future outcomes on a similar task (e.g., "I'm just not smart enough.").
- *Effort* is an internal, unstable, and controllable cause of success or failure. If a student attributes an academic failure to a lack of effort, it is within his or her control to modify that effort in order to improve future outcomes. The solution may be to work harder, but it may very well be to work differently<sup>16</sup>.

A summary of common attributions are presented in Table 2.

Table 2: Characteristics of Common Attributions

	Unstable	Stable
Internal	Effort (controllable)	Ability (uncontrollable)
External	Luck (uncontrollable)	Task Difficulty (uncontrollable)

We pause to discuss ability in depth, because it is often misunderstood. Dweck<sup>17</sup> has elaborated on student's attitudes towards ability and has proposed two mindsets about ability: *fixed mindset* and *growth mindset*. In the context of learning, a person with a *fixed mindset* believes that everyone has a set amount of intelligence (e.g. genetically pre-determined) that is stable and uncontrollable. In contrast, a person with a *growth mindset* believes that intelligence is unstable and can be fostered and increased. Prior research indicates that, students perform better when they and their teachers have a growth mindset, particularly when they encounter difficulties in the classroom<sup>18</sup>. Because ability becomes an internal, unstable, and controllable cause, like effort, a growth mindset promotes motivation.

This research reinforces the idea that students are more likely to persist and succeed in an activity if they attribute their success to internal, unstable attributes over which they can exert control (e.g., effort). Teachers can increase students' motivation by helping change their perceptions of the other three attributes (e.g., minimize luck, create student control over task difficulty, or foster a growth intelligence mindset).

### 2.3 Self-determination Theory

Self-determination theory emphasizes that students learn best when they are intrinsically motivated rather than extrinsically motivated. Students can be extrinsically motivated by rewards, grades, or others' opinions. In contrast, when a student is intrinsically motivated, she is led by "the inherent tendency to seek out novelty and challenges, to extend and exercise one's capacities, to explore, and to learn."<sup>19</sup>

People have three basic psychological needs that, when met, improve intrinsic motivation. These needs are autonomy, competence, and relatedness.

- *Autonomy* within the context of motivation is not independence but the need to perceive one's behavior as self-determined. Ryan and Deci<sup>20</sup> describe it as "an expression of the self, such that, even when actions are influenced by outside sources, the actors concur with those influences, feeling both initiative and value with regard to them."
- *Competence* is, according to Deci and Ryan, "feeling effective in one's ongoing interactions with the social environment and experiencing opportunities to exercise and express one's capacities."
- *Relatedness* is feeling a sense of unity with others. Deci and Ryan describe it as a "feeling connected to others, to caring for and being cared for by those others, to having a sense of 'belongingness' both with other individuals and with one's communities."

To motivate learning, instructors must facilitate intrinsic motivation by creating environments that support feelings of autonomy, competence and relatedness.

### 2.4 Expectancy-Value Theory

Motivational beliefs influence the behaviors that can affect achievement. According to Expectancy-Value Theory, students' motivation increases when they believe that they can complete a task (*expectancy*) and they believe that the task is worth accomplishing (*value*)<sup>21 22</sup>.

In other words, students will be motivated to engage in important activities in which they feel they can succeed at, and avoid activities in which they feel likely to fail and which have little value to them.

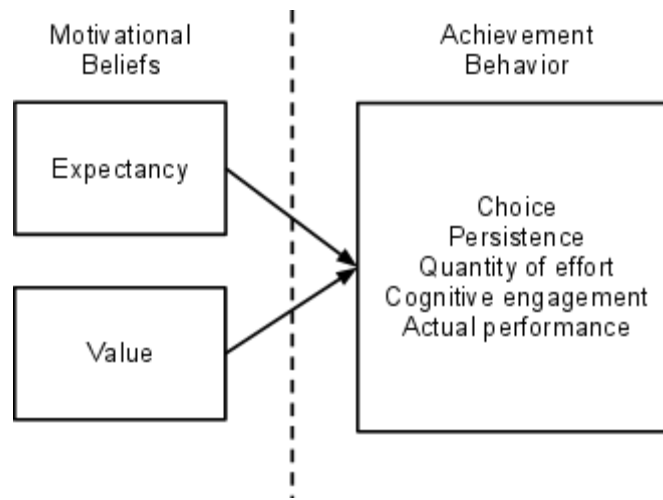


Figure 1 - Expectancy-value theory (Material drawn from Pintrich & Schunk, 1996)

Expectancy has two major components<sup>23</sup>. The first is the person's perceptions of the task (e.g., difficulty). The person's beliefs about her competence in this task, or on how well she can do the task, is the second one. These two components influence a person's determination of whether success is possible in any given task.

Some of the components that influence a person's determination of the value of a task are:

- the importance of doing well on a task,
- the enjoyment gained from doing the task, sometimes called the interest on the task.
- the usefulness of a task,
- the cost of engaging in a task, instead of doing other things, in terms of time, effort and emotional cost<sup>24</sup>.

According to this theory, teachers can motivate students by helping them understand the utility or importance of the tasks and concepts, and creating environments in which students feel they can succeed. For example, the teacher might create some early, mildly challenging successes for the students to build their confidence. These may be problems that are clearly related to what the students will face when they go into practice.

## 2.5 Summary of theories

This section presented four leading motivation theories: goal theory, attribution theory, self-determination theory, and expectancy-value theory. TAs do not need to pick one theory ("the correct one") to guide their work because all of them provide some insight into the multiple factors that contribute to, or hinder, students' motivation to learn. In fact, many of these theories overlap (e.g., competence and expectancy) or are complementary (e.g., Dan Pink<sup>25</sup> argues for a hybrid theory that incorporates value from expectancy-value theory into self-determination

theory). Factors TAs should consider include, but are not limited to: task value, feeling of self-efficacy, competence, relatedness, autonomy, control, and types of goals.

### **3 Tips for How TAs Can Motivate Engineering Students**

Because previous work on motivation theories in the classroom has focused on the actions of faculty, many teaching tips (e.g., create project-based courses) do not directly apply to what TAs can change. We focus on providing attitudes and actions that engineering TAs can use to help motivate students independent of the level of control they have over course design. We describe how engineering teaching assistants can promote motivation within the context of their typical teaching duties: facilitating discussion sections, holding office hours, providing feedback (grading), assisting students in laboratory settings, and creating problem sets and solutions.

In this section, we particularly try to connect each tip to the theory or theories that justify it. The Appendix provides a quick reference guide to connect the teaching tips with the various theories. We encourage TAs to not just enact tips without understanding why those tips are important, but rather understand how each action or attitude can help meet your students' emotional and social needs. We hope that this explicit connection between theory and practice will help TAs adopt an engineering approach as they work to improve their teaching: Assess the problem, strategically apply changes that aim to address the problem, and evaluate the effectiveness of the solution.

#### **3.1 Organizing a Motivating Discussion Section**

##### *3.1.1 Sharing choices*

In the traditional view of the classroom, the teacher is the authority and the students are expected to follow and obey the teacher's directions. In this model, the teacher makes all of the decisions about what will be taught, what tasks will be completed, and when things will be done. This style of teaching can become demotivating if students perceive that they cannot succeed within certain constraints and they can do nothing to change those constraints<sup>26</sup>.

A TA can promote a sense of control, autonomy, value, and approach goals by inviting students to help make classroom organization decisions. The TA can offer to adjust what types of tasks are conducted, how those tasks are pursued, or when tasks are completed. For example, a TA might spend five minutes reviewing a hard homework problem because the students requested help. TAs can promote motivation by routinely soliciting student's opinions of how the classroom should be structured and honoring those opinions when able.

##### *3.1.2 Scaffolding*

Scaffolding is the practice of giving students more control or responsibility as the students can handle the autonomy and difficulty. Steadily increasing the level of complexity is a teaching strategy often used by engineering faculty<sup>27</sup>. For example, when creating homework assignments at the start of the course, the TA might give students several short steps to achieve within a larger design problem (e.g., create a worksheet with a partial free-body diagram), but then offer fewer steps in design problems later in the semester (e.g., no worksheet). A TA can also begin the semester with more non-negotiable structure to the discussion section at the

beginning of the course, but give students more choices for class structure as the course progresses. Scaffolding improves motivation by supporting expectancy and competence.

### 3.1.3 Peer-to-peer instruction

Peer-to-peer instruction can improve students' sense of relatedness and promote a mastery orientation. Two particularly effective modes of peer instruction are think-pair-share<sup>28</sup> and Jigsaw<sup>29</sup>.

#### Think-pair-share instruction cycle

1. TA poses a question or problem
2. TA tells students that they have a short period of time to *think* about their answer
3. Students are told to turn to a neighbor. The *pair* must compare their answers for a second short period of time.
4. The TA then asks all students or a couple pairs to *share* their answers.

#### Jigsaw

The jigsaw strategy is a cooperative learning technique where jigsaw teams are composed of students with designated areas of expertise. Students with common areas of expertise form expert teams who are responsible for mastering that area and for teaching that to their jigsaw team classmates<sup>30</sup>. Jigsaw is most effective when students learn to see their classmates and themselves as reliable, valuable sources of information.

Jigsaw is also a way for TAs to model engineering problem solving skills such as problem decomposition. In this technique, the problem is analyzed and split into distinct subproblems that can be more easily solved<sup>31</sup>.

### 3.1.4 Additional Tips

- Help students see the relevance of what they are learning<sup>32</sup>. Point out where and when students will use knowledge<sup>33 34</sup>. Find those ideas and topics that are pervasive throughout your discipline (e.g., equilibrium, conservation laws, state machines) and emphasize those in your discussions. Use examples that point out how the topic can be applied to students' lives.
- Communicate high expectations and expect your students to come to class prepared to meet them. For example, if you assign a reading assignment, conduct class as if the students have read it (don't assume they will not read it because a fellow teacher told you that they won't!).
- Establish appropriate ground rules for the discussion on the first day of class. Discuss with students the reasons for the rules<sup>35</sup>.
- Remind students of ground rules frequently, but be willing to negotiate or adjust them if there is a problem with them.
- Enforce ground rules.
- Rotate leadership of the discussion among different students. Give students the chance to develop leadership skills and teaching skills, because these skills can boost expectancy and a sense of competence.



## 3.2 Creating Motivating Encounters in the Classroom and in Office Hours

The literature explains that autonomy-supportive teachers spend more time listening, articulate fewer directives, ask more questions about what the student wants, verbalize fewer solutions to problems, make more empathetic statements, and offer greater support for students' internalization of learning goals (e.g., providing more rationale for why an assignment should be accomplished or for the value of the learning goals)<sup>36,37</sup>.

As they talk with students, TAs need to be conscious of how different phrasings of the same idea change students' attitudes. For example, although the phrase "I don't want you to fail" communicates care, it emphasizes a fear of failure (avoidance orientation). On the other hand, phrases like: "I want to see you exceed my expectations," "I want you to be able to solve this type of problem with your eyes closed," or "I want you to identify the principle that applies to this type of problem as soon as you read it" encourage an approach orientation.

### 3.2.1 *Avoid complements about a student's character or ability, but complement specific actions*

Avoid complements about a student's character (e.g., you're such a hard worker!) or ability (e.g., you're so smart!) but instead complement specific actions (e.g., that was a hard problem, I am impressed that you did not give up!)<sup>38</sup>. Complements about a student's character can lead students to believe that their chance of success is no longer internal or controllable. For example, a student may explain a failure by saying: "The teacher doesn't like me" or "I just had a bad day." (cause: luck - external, unstable, little control), or may say: "I'm just not good at math" or "everyone else is smarter than me" (ability - internal, stable, little control). Complementing hard work can also promote an approach state, because it rewards something positive that students can pursue.

### 3.2.2 *Wait longer after asking questions*

The typical instructor waits less than one second for students to respond after asking a question<sup>39</sup> before they rephrase the question, answer the question, or worse, move on to the next idea. Try to always wait at least three to seven seconds after asking a question to give students a chance to think over the question. Alternatively, don't allow a student to answer for at least five seconds so that all students can think about the question. Longer wait time can improve students' sense of relatedness, because the wait time communicates that the students are valued. Longer wait time also communicates expectancy and a sense of competence as the wait time communicates that the instructor truly believes that the students can make valuable contributions.

### 3.2.3 *Ask open-ended questions*

A close-ended question is a question with a well-defined and expected answer. For example, "Do you agree?" or "What equation do we use for this problem?" An open-ended question is a question that does not have a single answer. For example, "Explain to me how you tried to solve this problem" or "How did you come to that decision in your design." Open-ended

questions promote motivation because they communicate that students can make a valuable contribution to the classroom which promotes a sense of competence and expectancy.

### *3.2.4 Emphasize what students will be able to do, not what grade they will receive*

To promote a mastery mindset, encourage students to work hard because of what they will be able to do rather than because they can get a good grade. For example, discuss how the material will be useful on the job or enables students to become innovators. Emphasizing what students will be able to do can also promote students' sense of value as they will understand how they will be able to use their knowledge and how their knowledge will benefit them.

### *3.2.5 Additional Tips*

- Be available
- Acknowledge student contributions
- Regularly check for understanding rather than assuming that a student understands
- Redirect student's questions to other students
- Let students vote on an office hour time
- Ask students to submit questions before class

## 3.3 Providing Motivating Feedback and Grading Schemes

### *3.3.1 Avoid grading on a curve*

“Grading on a curve” is a grading method that assumes grades in a class should be distributed along a bell curve or some other predetermined distribution. The average score for a test becomes a B or C and the rest of the scores are distributed accordingly. This grading scheme causes only a few students to receive As or Fs and most receive Bs or Cs. This practice encourages performance mentality by forcing students to focus on how their performance compares against their classmates' performance. Grading on a curve also demotivates because it reduces a student's sense of control by shifting the cause of success from internal to external. Grading on a curve can also erode relatedness as students may attribute their failures to high performing students or “curve-breakers.” This policy isolates high-performing students and low-performing students.

### *3.3.2 Use criteria grading*

As much as possible, adopt grading policies that promote the image and mentality that all students can succeed and pass the course. Criteria grading presents a clear standard (e.g., the class has 100 points: 90 points is an A, 80 points is a B, etc.) accompanied by a list of how students can earn those points. Criteria grading can further promote motivation if it uses strategic flexibility (no curving still!). For example, the criteria for grades can be lowered but never raised if the course assignments prove to be too difficult. The rules and methods for lowering the criteria must also be clearly defined. These clear standards promote motivation by emphasizing an internal locus of control, controllability, expectancy, and mastery.

Criteria for the grading policy should also reflect disciplinary or course values: Focus on giving more points to more important tasks rather than more difficult tasks. Grading based on importance can promote a sense of value and a mastery orientation. Also, avoid giving bonus points for arbitrary tasks, which are not related to the learning objectives of the course, like attending a talk or volunteering for a school event.

### *3.3.3 Use rubrics for grading*

Rubrics are assessment tools that can help students understand the criteria by which their work will be graded<sup>40</sup>. Rubrics indicate how points are allocated to different tasks, how tasks support different learning objectives, and the qualitatively different levels of performance for each task. Good rubrics describe very specific and measurable (observable) performance criteria. Rubrics can also reinforce disciplinary values (e.g., analytical thinking, good use of diagrams) that can increase students' understanding of what it means to become an engineer.

### *3.3.4 Provide timely feedback*

Provide timely feedback that students can use to identify which concepts they need to review to improve their performance. Timeliness is particularly important for homework. Students need homework feedback when they still have a chance to improve and demonstrate improved performance. If students feel homework serves no utility other than to get a grade, they will be less motivated to work on it than if they see it as an enjoyable, challenging experience that can help them learn or get valuable feedback before higher stakes assessments like exams.

Timely feedback can also be facilitated by the use of just-in-time teaching methods and the distribution of rubrics with assignments. If students know exactly what is expected of them, they can work towards a better understood goal.

### *3.3.5 Provide good feedback*

Students' resent getting homework assignments back with only a grade and no comments. This common time-saving practice gives students the impression that grades are arbitrarily assigned. They may attribute bad grades to bad luck or task difficulty instead of trying to reflect on what went wrong with their work and how to improve it.

Whether provided as written comments or verbally, good feedback<sup>41</sup> helps motivate students by:

1. clarifying what good performance is – For example, “The solution should take into account and respond to possible user errors” or “Good design minimizes the size the system”.
2. facilitating the development of self-assessment in learning – For example, “Have you considered other techniques that could be used to solve this problem?”
3. encouraging teacher and peer dialogue around learning – For example, “Help me understand how you tried to solve this problem”
4. encouraging positive motivational beliefs and self-esteem – For example, “I can tell you have made progress in understanding this concept” or “I know you can do better work than this, try to ...”

5. providing opportunities to close the gap between current and desired performance – For example, “In the future, keep an eye on memory management and you will have an efficient solution” or “This is an error we’ve seen before, you assumed  $x$ . Next time remember to consider  $y$  also when you solve a similar problem.”

These strategies can help foster feelings of autonomy, competence, and relatedness.

### *3.3.6 Keep and [maybe] share a list of common mistakes*

As you grade problem sets, keep a list of common mistakes with predetermined good feedback. This list will accelerate grading and ease the provision of meaningful feedback. The increased quality of feedback will increase your students’ sense of competence.

Depending on how you construct the list, you may also want to publish the list in a place for all students to see. This strategy can promote relatedness and expectancy, because students do not feel isolated as the “only one who made a mistake.”

### *3.3.7 Additional tips*

- Provide many opportunities for students to demonstrate what they have learned and gain points for their mastery of learning objectives. For example, give partial credit for correctly answering part of a question. Additional opportunities promote a sense of internal controllability and instability.
- As a practical matter, if you receive homework by e-mail or some other unsecured method, acknowledge you received it. It will not only prevent any student claims later on but it also increases students’ feelings of relatedness.

## 3.4 Motivating Students in Laboratory Settings

Many of the strategies previously discussed within the classroom, office hours, or feedback context can be used effectively in laboratory settings. In particular, the value of the learning tasks and their connections to any related courses should be explicitly stated. Additionally, TAs can help motivate student in laboratories by asking more open-ended questions and providing more opportunities for self-direction.

### *3.4.1 Provide opportunities for students to self-direct*

When TAs plan laboratories, it is preferable to provide opportunities for students to self-direct. Having to constantly ask for permission to proceed with laboratory procedures or request materials undermines students’ sense of autonomy and competence. Providing clear instructions, and facilitating an effective introduction to the laboratory should help minimize students’ dependence on the TA and still maintain safety.

### *3.4.2 Give fewer answers to questions*

TAs are hired to answer students’ lab questions, but some answers can be more motivating than others. Restrain from giving students solutions. Rather, try asking more open-

ended questions that help students find the answers for themselves. Open-ended questions refocus students' attention from a performance or avoidance mindset to a more approach or mastery mindset.

### *3.4.3 Rotate roles within the lab group*

When working in pairs or small teams in the laboratory, students often gravitate towards one role in which they feel most comfortable and usually one student will dominate time with the laboratory instruments while the others passively watch. TAs can require students to rotate between being the one that manipulates the laboratory equipment (the driver) and the one that makes sure that the driver is accurately following directions (the navigator)<sup>42</sup>. The driver may not see the instruction manual or interface with the TA and the navigator may not touch the laboratory equipment. TAs should choose either to have students switch roles after a fixed period of time (e.g., every 10-15 minutes) or require students to switch roles at certain check-points in the lab activities (e.g., switch roles after every major measurement). Role switching promotes relatedness as the team members must positively support each other to succeed. Furthermore it promotes a sense of competence and internal sense of control as the TA must communicate that they believe that all students can gain expertise with the laboratory equipment if they put forth the effort.

## 3.5 Creating Motivating Problem Sets and Solutions

When teaching assistants create homework assignments, there are several strategies they can use to motivate students to learn such as: focusing on what is important to learn not just what is difficult, challenging students with problems that are complex but still within their grasp, providing clear instructions, creating and distributing rubrics.

### *3.5.1 Focusing on what is important to learn not just what is difficult*

Create problems that will focus on what is important to learn not just what is difficult. Too often assignments consist of trick questions that do not contribute to helping students understand the concepts being studied. By emphasizing what is important in the problem sets, TAs can help students focus their efforts and continue to work harder on mastering important problems.

The important problems should be authentic (i.e. "real world") problems that the students will find in engineering practice. This strategy can help students realize the relevance and value of the underlying theories been used<sup>43</sup>.

### *3.5.2 Problems should challenge students but still be within their grasp*

Homework problems should challenge students but still be achievable. As previously discussed, students inherently seek out novelty and challenge. Challenging problems can help increase intrinsic motivation but challenges that are too difficult for students' current capabilities can frustrate them and inadvertently make them feel incompetent. One option is to create problems that present new angles or considerations to problems students had already seen in class before. This strategy can help increase students feeling of competence and expectancy<sup>44</sup>.

### 3.5.3 *Varying the difficulty levels of the problems*

Another strategy is to vary the difficulty levels of the problems. TAs can use the, previously discussed, scaffolding strategy to organize assignments as a series of increasingly more difficult problems. In this way, students would experience success in some of the early problems and then be increasingly challenged in later ones. Early successes help increase feelings of competence and increase expectations for future success<sup>45 46</sup>. On the other hand, assignments consisting only of difficult problems can frustrate students and discourage them from persevering to complete the assignment.

### 3.5.4 *Providing clear instructions*

Providing clear assignment instructions also helps motivate students. Making the learning goals, expected performance standards and criteria that will be used to grade that performance very clear can contribute to students' sense of controllability, autonomy, and task value. It also reinforces approach-mastery orientation.

### 3.5.5 *Creating and distributing rubrics*

As previously discussed, one way to provide clear information about grading criteria is to create rubrics. When rubrics are distributed with assignments, they help communicate in very clear terms performance expectations. They “divide an assignment into its component parts and objectives, and provides a detailed description of what constitutes acceptable and unacceptable levels of performance for each part”<sup>47</sup>. Although it is presented here as the last step in creating homework, generating the rubric could be done at the beginning of the process as a way to determine what is important to evaluate before actually creating the problems.

## **4 Conclusion**

In this paper, we presented four leading motivation theories: attribution theory, self-determination theory, expectancy-value theory, and goal theory. Considering the multiple factors that contribute to, or hinder, students' motivation to learn, we described strategies that may be used by Teaching Assistants to motivate their students to learn. Even though most of the strategies themselves are simple to implement, TAs may initially feel overwhelmed by the number of possible strategies and the process of selecting them.

To put these strategies into practice we suggest adopting an engineering approach of incremental improvements. The first step would be to determine student needs. This is done by observing and listening deeply to students during interactions with TAs, teachers, and peers. From those interactions, establish which of those needs are priorities that must be immediately addressed. TAs can then consider which of the strategies presented in this paper can address the identified needs and select one or two strategies to incorporate at a time. Finally, it is important to evaluate the effectiveness of the motivation strategies being implemented through self-assessment and student feedback.

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## 6 Appendix – Summary of Strategies and Supporting Motivation Theory

	Attribution Theory			Self-Determination Theory			Expectancy-Value		Goal Theory	
	Locus of control	Stability	Controllability	Autonomy	Competence	Relatedness	Expectancy	Value	Approach	Mastery
<b>Classroom Organization</b>										
Shared choices	x	x	x	x		x		x	x	
Scaffolding (Create structures ... confidence of success)		x	x		x		x			
Peer-to-peer instruction	x		x	x	x	x	x			x
Increased Relevance				x				x	x	x
Expect preparation	x		x		x		x		x	x
Establish appropriate ground rules		x		depends	x		x			
Remind students of ground rules					x		x			
Enforce ground rules					x		x			
Rotate leadership of the discussion	x		x	x	x	x	x			x
<b>Classroom and Office Hour Interactions</b>										
Be available						x		x	x	
Open-ended questions	x			x	x		x	x		x
Longer wait time	x					x		x		x
Acknowledge student contributions	x	x	x	x	x		x		x	x
Check for understanding	x		x	x	x		x			x
Redirect students' questions	x				x	x	x	x		x
Let students vote on office hour time	x			x		x				
Question submission before class	x		x	x	x		x			
<b>Feedback/Grading</b>										
Rubric grading	x		x		x		x		x	x
Criteria grading (no curve!)	x		x		x		x		x	x
Provide prompt/timely feedback			x	x		x			x	x
Communicate high expectations: I want to see you exceed my expectations	x		x		x		x			
Give specific suggestions for improvement			x				x			x

	Attribution Theory			Self-Determination Theory			Expectancy-Value		Goal Theory	
	Locus of control	Stability	Controllability	Autonomy	Competence	Relatedness	Expectancy	Value	Approach	Mastery
Avoid complements about a student's character or ability		x	x							
Complement specific actions within the student's control			x							
Acknowledge receiving assignments		x				x				
Share a list of common mistakes						x				x
<b>Laboratory Settings</b>										
Give fewer answers to questions					x					x
Rotate roles within the lab group (quality control versus hands-on)			x	x	x					
Provide opportunities for self-direction	x		x	x	x		x			
<b>Creation of homework assignments</b>										
Focus on what is important and not just what is difficult								x	x	x
Create problems that will challenge students but are still within their grasp			x		x		x	x	x	x
Vary difficulty levels of the problems					x		x		x	x
Provide clear assignment instructions, (goals, criteria, expected standards)	x	x	x	x	x			x	x	x
Create and distribute rubrics with assignments	x	x	x	x	x		x	x	x	x