Slide 1:

I want to thank ISFT 2020 committee, especially, Professor Kumar for inviting me to you to give a talk here about my favorite topic of engineering education. The learning process for our students has three essential components – curriculum, assessment and instruction. As individual or as a group of teachers, we at least have control of how we assess and how we instruct. Many a times, we as teachers get so content oriented that we believe that our work is done if we teach the content and through some assessment, we come to believe that our students know the content.

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But when we go out there next semester, let's think of the outcomes of the course to fall under three categories, and the first step would be to magnify this in the syllabus and the first day of class.

Cognitive: "What will students completing this course know?"

Behavioral: "What will students completing this course be able to do?"

Affective: "What will students completing this course care about or think?"

Slide 3:

No discussion on engineering education is complete without talking about active learning. We do not need to belabor the effectiveness of active learning. The evidence being that student performance on examinations and concept inventories increased by an effect size of 0.47, which means that it improved by about half a standard deviation. To give the effect size a meaning in education, an effect size of around 0.2 is considered to be small, 0.5 is considered to be medium and 0.8 is looked as large. We cannot expect large effect sizes with singular type

of interventions except for one-on-one tutoring. Bloom claimed that the effect size for one-on-one tutoring was 2.0, but because of some extreme conditions he posed on mastery, it should be corrected to 0.8.

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Various teaching techniques are being practiced by us including Lecturing, Blended, Flipped, Hybrid, Adaptive, Problem based, and Case study. The psychological theory known as the "paradox of choice," says that the more options we have, the more anxiety we feel. Those of us who want to adopt newer techniques are getting confused and overwhelmed. Articles are written even in the main stream medium about lecturing, active learning, banning technology in class, getting rid of assessment, etc. What is an instructor supposed to do? The truth is that only extreme views get heard and publicized. No one wants to compromise as if compromise is a dirty word.

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Since 2013, we have been conducting research on the use of flipped classrooms in a course in Numerical Methods, and we have been unable to reject the null hypothesis that the student performance and student satisfaction in flipped and blended classes is the same. We are finding some merit to use adaptive learning in the pre-class learning to improve these metrics of the flipped classroom. My definition of blended class is an active learning class – the active learning reduces the content covered and that is off-loaded as an online activity but after the class. The student does not have to do any pre-class learning unless they are pre-requisite materials. We are not comparing with traditional classrooms as that would be not fair. In the same abstract where Freeman and his colleagues concluded that the effect size is about 0.5 for active learning vs traditional classrooms, they also mentioned this - The results raise questions about the continued use of

traditional lecturing as a control in research studies. This part is mostly ignored by my fellow education researchers – most continue to compare any intervention with the traditional lecture. They show small to medium effect sizes which only shows that it is better than traditional lecture, but not a blended class. I am not making a case neither for the flipped class or the traditional lecture, I am making the case for meeting in the middle.

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Having said this, practice tests have a large effect size. Practice tests does not mean teaching to the test. Make many tests. Make them by chapter.

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We all know about students cramming for the test, and it works if the tests are traditional. Make them cumulative and you will not make any friends but you will reduce the advantage of cramming and improve long-term memory of the concepts.

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How do we bring this all together for improving the performance of our students as well as their satisfaction? UDL – Universal design for learning has its roots in universal design for architecture – an example would be making building more accessible not just for the handicapped, but the elderly, parents with strollers. That concept was introduced by Professor Nace of North Carolina State University in the 1970s. What Nace believed in was that rather than retrofitting buildings, it is better to include UD in the architecture itself. UDL is extending the UD for learning. An example would be close-captioning and transcribing a video lecture. Yes, this is important for the hearing-impaired but for the general population, captions and transcripts are known to improve

comprehension, helps nonnative language viewers, and maybe if one has an accent of his own, it makes your contribution accessible to them.

What makes UDL attractive is that it is based on principles which are embedded in what we know about learning sciences as well. UDL has three principles.

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The first principle is giving multiple means of representation as we have done in our numerical methods open courseware that includes videos with close captions and transcripts, PPTs, simulations, real world applications, assessments, etc. This activates the recognition networks – the what of learning.

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The second principle is giving multiple means of action and expression and includes giving opportunities to students to express what they have learned in different ways. So our assessment should not be limited to just tests and final exams, but to short quizzes, projects, etc. You may also give them choices - I gave them an option for final exam or a final project. I have even asked engineering students to write poems, make 10-second Instagram videos, meme, and write essays. These assignments activate the strategic networks – the how of learning.

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The third principle is having multiple means of engagement to stay motivated where we may be using clickers, group projects, think-pair-share, and hands-on experience. These activate the affective networks – the why of learning. This is a simple framework, more of a philosophy of how we should design a course. Because at the end we want our students to know the what, why and how of learning. We want them

to know the content, able to apply it, and care about what they learned.

Slide 12:

To end the talk, you get a lifetime warranty to discuss anything I have talked about here. There are a number of ways to get in touch with me. Yes, the time in the lifetime warranty is my lifetime, not yours, as you all look much younger than me.