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Shock to the System: How a Teaching and Learning Model Held up in a Global Pandemic

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Shock to the System: How a Teaching and Learning Model Held up in a Global Pandemic (Work in Progress)

In the late 1990s, the Department of Civil and Mechanical Engineering at the U.S. Military Academy (West Point) formulated a teaching model which guided the training of new faculty. The model served faculty well as they provided instruction and developed learning activities. The model remained unchanged for about 15 years until a team of faculty conducted a methodical review of the literature, reflected on desired outcomes, and deliberated about the role that this model played in achieving the institution and department's mission and vision. The result was an updated teaching and learning model which was presented at the ASEE National Convention in 2017. As was emphasized in a previous paper, the faculty believed strongly that the teaching and learning model be viewed as a living document that must be applied and regularly challenged, discussed, and updated to ensure it remained relevant.

When the coronavirus pandemic began in early 2020, the institution, which had very limited experience providing online instruction, sent students home, and switched to delivering fully remote courses within less than one week. Like most other academic institutions, this was a significant shock to the teaching and learning environment; faculty rapidly learned new tools and tried new techniques to teach, engage, and interact with students. After the semester ended, the department formed teams of faculty to devote a portion of the summer to gathering lessons learned from the spring term, examining the literature about online education, and providing recommendations for the fall term. These activities led to discussions about how well the existing teaching and learning model applied to the vastly different environment of online versus in-person education. This inspired the faculty to a thorough examination of the living document.

During the subsequent fall term, formal faculty discussions about the model were facilitated. Topics from these discussions were grouped as follows: (1) aspects of the model that can be applied unchanged in the online environment, (2) aspects of the model that are difficult or impossible to apply in the online environment, and (3) ideas that need to be included in the model to support the online environment. The discussions included topics unrelated to the online environment, highlighting important aspects of the model that deserve additional consideration. Results from these faculty discussions will inform a team of faculty that will develop an updated version of the model in the summer of 2021.

This work in progress paper summarizes the results from the discussions, highlights preliminary conclusions, and describes future work. This will be of interest to any engineering educator interested in developing and using a teaching and learning model as a guidepost for themselves or their department. This will also be of interest to educators desiring a better understanding of the similarities and differences between in-person and remote teaching.

Introduction

History of the Model of Teaching & Learning

In the late 1990s, the Department of Civil and Mechanical Engineering (D/CME) at the U.S. Military Academy (West Point) formulated a teaching model which guided the training of new faculty. The model was developed from theoretical research and served faculty well as they developed learning activities and provided instruction. The model remained unchanged for about fifteen years until a team of faculty conducted a methodical review of the literature, reflected on desired outcomes, and deliberated about the role that this model played in achieving the institution and department's mission and vision. The result was an updated teaching *and learning* model which was presented at the ASEE National Convention in 2017, shown in Figure 1 [1]. The faculty believed strongly that the teaching and learning model be viewed as a living document that must be regularly challenged, discussed, and updated to ensure it remains relevant with the current research and understanding of how people most effectively learn. However, it is important to note that the model does not exist as a list of best practices—instead, it is a collection of fundamental components of teaching and learning within which a variety of practices can be applied.

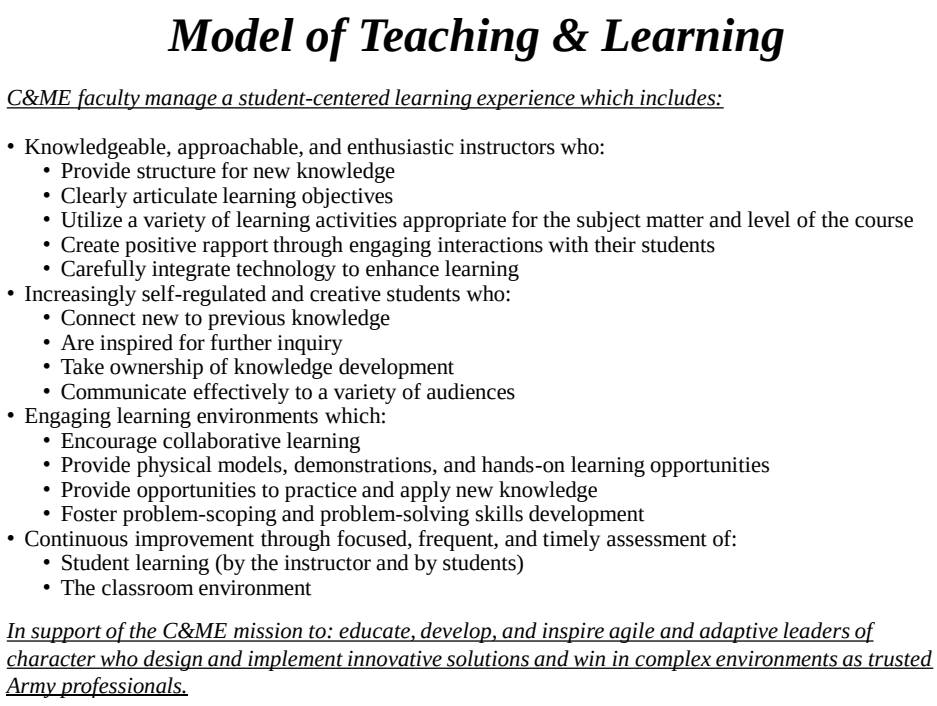


Figure 1 Model of Teaching and Learning (adapted from [1]).

The four main aspects of the model are **instructors**, **students**, **learning environments**, and **assessments**. Each aspect is described as an inspirational vision rather than a checklist of must-have characteristics. Nearly all the statements within each of the four aspects begin with action verbs that describe something a person does, or an environment provides. Importantly, the model is written with positive, empowering language. It articulates what a good teacher does, rather

than a list of things not to do. As with performance-based design, these statements are specific enough to be clear, but general enough to provide a framework within which faculty can operate and experiment with new methods.

Other Models of Teaching & Learning

The faculty are confident that this model is valuable and that it, or something similar, could be adopted by other institutions. It is rooted in the educational literature and has proven effective for implementation by junior and senior faculty. It was encouraging to find that the D/CME is not the only program or organization to believe that teaching and learning models are valuable. For many years the D/CME teaching model was identical to the model used within the American Society of Civil Engineers (ASCE) Excellence in Civil Engineering Education (ExCEEd) Teaching Workshop (ETW) [2]. The ETW is a week-long teacher-training program that traces its roots back to the incoming instructor summer workshop conducted annually within the D/CME [3]. The ETW became its own separate entity in 1998, and the D/CME and ETW's teaching model remained identical until the D/CME undertook the mission of updating its own model in 2017 as previously mentioned.

Since 2017, several other institutions have shared their visions, or models, of effective teaching. The Colorado School of Mines has a *Vision of Highly Effective Teaching* that identifies four characteristics (supportive of students, focused on learning, intentionally designed, and reflective) that are core to highly effective teaching based on a review of the empirical literature on teaching and learning. The Colorado School of Mines Vision of Highly Effective Teaching identifies several other schools that have a form of teaching model, including: the University of Oregon, the University of Southern California, the University of Michigan (modified from Carnegie Mellon University), Pennsylvania State University, and the University of Tennessee at Chattanooga [4].

Shock to the System: Rapid Switch to Remote Teaching and Learning

Like many other institutions, as the coronavirus pandemic swept the globe in the spring of 2020, West Point sent students home and switched to delivering fully remote courses in less than one week. Teachers everywhere quickly began learning new tools and trying new techniques to teach, engage, and interact with students. For most faculty at West Point, there was never a prior need to use any kind of remote teaching–synchronous or asynchronous. The nature of our academic institution did not require those modalities. The institution ramped up quickly but did not have internal resources or a wealth of experience to tap into.

After the semester ended, discussions across the faculty revealed that the influence of the teaching and learning model was clearly in mind while teaching remotely. Faculty described challenges maintaining rapport with students through only computer-based interactions. They shared things they did to engage and inspire students by providing videos of demonstrations or modifying the constraints on design projects to allow students to use common household items. They discussed methods used for the first-ever virtually hosted Projects Day—a West Point - wide, major event every spring term in which teams of seniors present the results from their year-long capstone design projects. These conversations led to the observation that many

elements of the model for teaching and learning clearly applied in this completely new environment, but concern was raised that other elements may be impossible to attain, and some aspects may be incompletely described.

Recognizing that the pandemic would not quickly end, the department formed teams of faculty to devote a portion of the summer to gathering lessons learned from the impacted spring term, examining the literature about online education, and providing recommendations for the fall term. Central to these discussions was how well the existing teaching and learning model applied in the vastly different environment of online versus in-person education. The faculty in the D/CME viewed this as an opportunity to assess our model and determine if it was only applicable to traditional in-person instruction. This prompted the faculty to schedule a series of formal discussions throughout the fall term to allow a critical review of the model. Because this review of the model was precipitated by the unique environment in which educators found themselves, this paper is largely focused on teaching and learning outside of a physical classroom or laboratory. This new environment may be described as remote teaching, distance education, virtual instruction, or online learning. As our faculty were new to any of these modalities, we used these terms interchangeably but soon learned that they are each unique. To ensure clear understanding, the terms remote, virtual, and online are defined for the purposes of this paper in Table 1. It should be noted that the faculty in the D/CME conducted remote teaching, both synchronous and asynchronous, almost exclusively in during the spring of 2020; thus, many of the other terms in Table 1 are not referenced later in this paper. Table 1 provides a definition for the various terms we were in use among the faculty.

Table 1 Definition of Terms

Term	**Definition**	**Source**
Remote Teaching	"contingent continuation of a face-to-face academic course when circumstances make it impossible for the class to meet physically"	[5]
Distance Education	"non-contingent delivery of a course designed from its origin to use remote means of instruction"	[5]
Virtual Instruction	"when a course is taught either solely online or when components of face-to-face instruction are taught online such as with Blackboard and other course management systems. Virtual instruction includes digitally transmitting class materials to students."	[6]
Online Instruction	"a course that has been developed with the intention for fully online delivery. … The learning experiences and instructional objects in an online course are typically fully-developed before the start of a semester."	[7]
Synchronous Learning	"education that happens in real time"	[8]
Asynchronous Learning	"forms of instruction/learning that do not occur in the same place or time. Asynchronous learning occurs without real-time interaction"	[8]

Methodology

After the spring 2020 semester ended, the D/CME formed teams of faculty to devote a portion of the summer to gathering lessons learned, examining the literature about online education, and providing recommendations for the fall term. Three teams were created to examine the following topics in depth: (1) Best Practices for Remote Learning, (2) Preparing Faculty to Implement Remote Learning, and (3) Preparing Safe In-Person Conditions in a Persistent COVID Environment. The teams were composed of four or five faculty members who had taught in the previous disrupted semester, were concurrently teaching in the summer semester, and/or were scheduled to teach in the subsequent fall semester. The faculty members met in their respective teams over the course of approximately one month and used various techniques to examine the problem and propose guidance to the department. The teams used surveys of their colleagues within the department to look inward for best practices and conducted searches of best practices at other similar institutions of higher learning. Some of the literature was developed just-in-time to address new challenges posed by the pandemic, but others consulted resources focused on new student needs or advances in technology that create new opportunities [9]–[11]. At the conclusion of the month-long period, each team created and presented a product that captured the key points and lessons learned. These activities led to informal discussions about how well the existing teaching and learning model applied in the environment of online versus in-person education.

As the fall semester of AY2021 began, the department convened a series of faculty discussions to learn from each other's experience in the previous semester as we prepared for the next semester which was to be taught in at least a partially remote manner, examine the existing teaching and learning model through the lens of teaching and learning in a persistent COVID environment, and identify any necessary modifications to the model based on this recent experience.

These discussions sought to answer two research questions: (1) How well does the current Model of Teaching & Learning apply to remote education? And (2) What changes are needed to make the Model of Teaching & Learning applicable to a variety of modalities?

A mixed-mode research approach centered around three, hour-long formal discussions spaced throughout the semester. Each discussion had a different principle focus along with specific questions to address. The facilitator for each discussion completed preliminary research to assist in framing the discussion questions. All faculty in the department were encouraged to participate, either in person or remotely, to gather experiences from the more than 35 faculty members with varying degrees of teaching experience. The first discussion did not occur until after the first two weeks of class in the fall semester to give all faculty an opportunity to experience teaching in the COVID environment and focused on identifying elements of the model that faculty were having the most difficulty implementing in the current environment. The second discussion happened two weeks after the first and focused on identifying gaps in the model. The third discussion occurred just past the half-way mark of the term and centered around identifying elements of the model that needed updating. These faculty discussions, each led by a different faculty member,

challenged the language and student engagement methods in the department's existing teaching and learning model.

Primary conclusions from the discussions included:

- New language that challenged conventional thinking on the boundaries and engagement strategies of the learning environment.
- Many elements of the model were able to be applied in the online environment with little to no adjustment necessary. The model was rooted in the teaching and learning literature in such a way that it was largely modality independent.
- Some elements of the model were difficult to apply when the change to a fully remote online environment was made. While many faculty were able to apply the important concepts, it was challenging and, in some cases, expensive (from both time and financial perspectives) to do so.
- Several elements were necessary in the fully remote environment that were not included, or at least not immediately apparent, in the model.

What from the model has been able to be applied unchanged in the online environment?

Through the discussions, it became clear that there were several elements of the teaching and learning model that applied in the online environment in the same way as in a traditional in-person classroom.

Instructors

The need for instructors to provide structure for new knowledge and clearly articulate learning objectives remained critically important and able to be accomplished regardless of the environment in which the teaching and learning occurs. An asynchronous lesson benefits from a structured organization and a clear statement of essential learning objectives just like an in-person lesson does. By doing so, instructors enable students to connect new to previous knowledge, another element of the model that applies unchanged in the online environment.

Students

Student ownership of their own learning is another element of the model that can be applied unchanged regardless of environment. During the Spring 2020 semester, students operating outside of the traditional classroom environment had to take more ownership for their learning than they had before the pandemic. The advantages of increased personal ownership were noted by some members of our faculty as a positive improvement and some discussion focused on how to maintain this as we return to in-person learning. Faculty also noted that not all students took ownership of their learning in the remote learning environment. In some cases, this was due to lack of personal motivation, but in other cases it was because of inadequate access to resources such as a quiet learning space or internet connectivity. There are likely other reasons such as anxiety, mental health, or feelings of isolation that could have impacted the students' ownership and affected their personal motivation; however, this paper does not examine those areas. The

main point, regarding the teaching and learning model, is that students do need to have ownership of their own learning and that this is even more critical in a remote environment.

Opportunities for students to communicate effectively to a variety of audiences remained much the same in the remote environment. Writing assignments were submitted electronically rather than hard copy. Presentations were given using online meeting software such as Microsoft (MS) Teams. Prior to the Spring 2020 semester, few instructors required students to create video presentations, but this became a more popular assignment when teaching remotely. In fact, during Projects Day, an annual event during which seniors present their capstone design projects to an audience of faculty, students, and project sponsors, all teams were required to create a video presentation that was streamed and followed by a live question-and-answer session on MS Teams. The result was an event that was more broadly attended than in previous years as more sponsors were able to attend remotely and parents of students were also able to join.

Learning Environment

Regardless of the modality of instruction, opportunities for students to practice and apply new knowledge remained a central element of courses. While instructors had to adjust to electronic submissions, as opposed to hard copy, the assignments themselves were virtually unchanged. Problem sets remained the primary way for students to practice what they were learning.

What from the model was difficult to apply in the online environment?

In contrast to above, there are several aspects of the model that were not readily applicable to the online environment.

Instructors

A tenet of the model is to create positive rapport through positive interactions. Some of the best rapport development happens in informal and unplanned ways. When students are not physically present, faculty miss out on the opportunity for pre-class/post-class discussion, popping into the student lounge to see what students are working on, or even a short conversation in the hallways. Specific efforts can be made to establish and maintain rapport with students who are online (e.g. short interviews, having the virtual environment open for several minutes before and after class, etc.), but faculty agreed that this was much different than building and maintaining rapport in person. It was noted as particularly difficult when instruction was provided asynchronously and, in these cases, scheduling individual conversations with students became even more important. Additional research is necessary to understand proven techniques for building rapport in a variety of teaching modalities.

Learning Environment

Another tenet of the model of teaching and learning is the utilization of a variety of learning activities. This recognizes the need for frequent transitions in instructional methods to keep students engaged. It also allows for better connection with a variety of learning style preferences. There is a perception among the faculty that a classroom setting provides more flexibility to

transition between learning activities; for example, one can easily move from a large group discussion, to a demonstration, to small group work at the boards, to individual reflection, and back to large group discussion. Technology exists to replicate each of those in a virtual setting, but due to limited experience teaching in a remote environment, our faculty reported that it was difficult to implement each of these activities in a single lesson. As is true for managing successful transitions between activities in an in-person classroom, successful transitions in a remote teaching environment require practice and it is the belief of the faculty that managing remote teaching transitions requires much more practice than traditional in-person activities. Additional research is necessary to understand if the same learning effect from these various activities is achieved when remote. Importantly, identifying proven learning activities that technology facilitates is important future work.

The phrase "Carefully integrate technology to enhance learning" now seems like an ironic aspect of the model. Before COVID, this statement felt outdated. It originated from the first version of the department's model in the 1990s when educators were concerned about the effect that computers and electronic slides could have in the classroom. Decades later, many faculty now seamlessly integrate technology in the classroom to enhance the learning experience. They capitalize on projected images and videos to help students connect theoretical concepts to the real world. Faculty use simulation software to assist visualization. Despite this, when COVID encouraged the shift to virtual education, the explosion of technological tools was overwhelming, and the statement to "carefully integrate technology to enhance learning" became even more valid. The COVID environment highlighted the importance of technology as the environment itself went virtual, but it also became a challenge to keep up with the continuous stream of application updates and new features. Just like the concern implied from the original statement, poorly integrated technology becomes a major distraction to learning.

Collaborative learning was also found to be a challenge to implement. Students scattered across time zones made finding meeting times difficult. Connectivity issues, equipment access, and software features also complicated the situation. Much progress has been made to improve virtual collaboration (e.g. breakout rooms, familiarization with shared documents, etc.) but initially it was quite difficult to implement this aspect of the model.

Providing physical models, demonstrations, and hands-on-learning experiences requires more forethought and creativity in a remote environment. Not all demonstrations or models achieve the desired effect as well via a computer screen as they do in the classroom. Many of the sensory effects are lost when only viewed on camera. Showing crack propagation on the screen is not as effective as passing around a sample in the classroom. Watching a lab test is not engaging or effective as students completing the experiment themselves. Consideration had to be given to items that students may have at home or in their dorms that would help demonstrate a particular phenomenon. In some cases, students were asked to ensure that they had certain items assembled and available before a lesson began. In other cases, items were mailed to students in advance such as small jars of soil or a small bag of K'Nex®.

What is missing from the model considering the online environment?

When assessing the effectiveness of the model as it relates to the online environment, the D/CME also focused on potential gaps, or missing pieces.

Learning Environment

One of the subcomponents of assessment is that of the classroom environment. In the faculty discussions, "classroom environment" carried a brick-and-mortar interpretation, whereas learning environment seemed less constrictive. Word choice led the discussion deeper into what about the environment should be assessed when pursuing excellent teaching and learning. This is a topic for further discussion and research to better understand the literature about assessing the remote or virtual teaching and learning environment. At this point it is unclear if this specific element of the model will be updated or if it remains applicable as currently written.

An Explanatory Commentary

The model has been widely viewed by faculty from the lens of the one-pager (Figure 1). An accompanying document, see Appendix A, exists to guide faculty through implementation, especially during their first year of teaching but is rarely, if ever, mentioned among the faculty and many members were unaware that this document exited. The guide, referred to as commentary slides, underpins and provides clarification for the more general language seen in the model one-pager. While the one-pager has made its way into the department's new instructor training, teaching portfolios, and posters throughout the departmental facilities, the commentary slides have not been as readily accessible or discussed. In analyzing the model in response to COVID, the commentary slides were remembered and reviewed. The commentary slides provide greater depth for new instructors understanding and implementing the model for the first time, but also serve as a guidepost for seasoned instructors searching for greater application and understanding. They are essentially used to express the totality of careful consideration that the department put into the model. As the model is updated, so too will these commentary slides. Doing so will provide a mechanism not just to describe the updates but to also provide an updated list of literature upon which the model is based.

Next Steps

Since this paper is a work in progress and the D/CME plans to use this assessment of our teaching and learning model to make any changes, the authors felt a "next steps" section was appropriate to conclude the paper. Preliminary answers to the two research questions are:

(1) How well does the current Model of Teaching & Learning apply to remote education? In short, quite well! Nothing in the model proved impossible to implement in a virtual environment but several elements required additional planning, effort, and/or creativity to employ. The discussions that took place during the fall 2020 term highlighted areas in which the model may benefit from improved clarity or updated language.

(2) What changes are needed to make the Model of Teaching & Learning applicable to a variety of modalities? There may be a few, particularly as related to clearly describing the learning environment. Initial conclusions suggest that few if any changes are necessary specifically related to different modalities – instead, the model remains broadly applicable to a variety of teaching modalities. Additional research to better understand the literature about remote and virtual instruction is necessary to address this question more completely. It is likely that while the model itself may remain unchanged in regard to modalities, the commentary slides will certainly provide references and examples of implementing the model in a variety of modalities appropriate to our institution.

Over the next 6-8 months, the department will create an ad hoc committee to develop suggested modifications to the model. These suggestions will not be based only on experiences within the department. Staying true to the original intent of the first teaching model developed in the 1990s, any updates must be rooted in the literature. Because our faculty had little experience with remote, online, and virtual education, we recognize that a significant portion of updating the model must include rigorous and thorough review of the literature related to this different environment.

In addition to updating the model, the commentary slides will also be updated and together, the improved model and commentary is expected to be incorporated into the annual new instructor workshop beginning in the summer of 2022. The overall assessment has been beneficial in the continuous improvement process, and the authors feel strongly that having a teaching and learning model is something all programs should consider adopting if they do not already have one.

References

[1] B. Wambeke, B. E. Barry, and J. C. Bruhl, "Teaching Model as a Living Document," in *ASEE Annual Conference and Exposition*, 2017, [Online]. Available: https://peer.asee.org/28924.

[2] A. C. Estes, R. W. Welch, and S. J. Ressler, "The ExCEEd Teaching Model," *J. Prof. Issues Eng. Educ. Pract.*, vol. 131, no. 4, pp. 218–222, 2005, doi: 10.1061/(ASCE)1052-3928(2005)131:4(218).

[3] A. C. Estes *et al.*, "The ASCE ExCEEd Teaching Workshop: Assessing 20 Years of Instructional Development," *Int. J. Eng. Educ.*, vol. 35, no. 6(A), 2019, [Online]. Available: https://www.ijee.ie/contents/c350619A.html.

[4] Trefny Innovative Instructor, "A Vision of Highly Effective Teaching at Mines." Colorado School of Mines, [Online]. Available: https://trefnycenter.mines.edu/wp-content/uploads/sites/44/2019/03/Effective-Teaching.pdf.

[5] R. Kimball, "White Paper: Remote Teaching and Distance Education Working Group Proposal," West Point, NY, 2020. [Online]. Available: https://www.westpoint.edu/remote-teaching.

[6] Purdue University Copyright Office, "Virtual Instruction." https://www.lib.purdue.edu/uco/ForInstructors/virtual.html (accessed Feb. 15, 2021).

[7] Centre for Innovation in Teaching & Learning, "Remote vs. Online Instruction – Instruct-ional Resources." https://blog.citl.mun.ca/instructionalresources/remote-vs-online-instruction/ (accessed Feb. 15, 2021).

[8] D. M. Thomas and B. Wallen, "Remote Teaching Distance Education Working Group Report," West Point, NY, 2020. [Online]. Available: https://www.westpoint.edu/remote-teaching.

[9] R. Ringel, B. Tarallo, and L. Green, "5 Steps to Stay Focused When Teaching Online," *Harvard Business Publishing Education*, 2020. https://hbsp.harvard.edu/inspiring-minds/5-steps-to-stay-focused-when-teaching-online (accessed Feb. 28, 2021).

[10] H. R. Taft, "How to Quickly (and Safely) Move a Lab Course Online," *The Chronicle of Higher Education*, Mar. 2020.

[11] F. Darby, "How to Be a Better Online Teacher," *The Chronicle of Higher Education*, Apr. 2019.

Appendix – Teaching and Learning Model Commentary Slides

When the Department of Civil and Mechanical Engineering at the U.S. Military Academy (West Point) published the updated model in 2017, they also created a series of "commentary" slides which summarized each of the sub-items within the four main categories of the model (e.g. "Provide structure for new knowledge.") While these commentary slides have not been as widely discussed across the faculty as the model itself, they provide important background. Each provides a concept summary explaining the main idea, lists citations of literature supporting the concept, and lists examples of how the concept may be applied within the courses our faculty teach. The original commentary slides are provided in the following pages.

UNITED STATES MILITARY ACADEMY
WEST POINT

…provide structure for new knowledge

Concept Summary:

Providing structure to new knowledge allows students to categorize concepts into meaningful pieces that can aid in memorization and retention. Faculty can help students structure new knowledge in ways that help in problem solving and recall. Learning science indicates that experts differ from novices in the ability to recognize meaningful patterns of information and structure their knowledge in ways that indicate a deep understanding of a subject.

Literature supporting the concept:

Bransford, et al. (1999)
Newstetter, W. C., & Svinicki, M. D. (2014)

Examples:

- Instructor uses lesson and course objectives to organize key learning points.
- Instructor develops a flow chart to discuss problem solving strategies and associated analytical steps.
- Instructor helps students classify problems based on overarching principles (Energy, N2L, etc.)
- Instructor asks students to draw a concept map of a set of concepts to demonstrate how they have connected the knowledge they have gained.

UNITED STATES MILITARY ACADEMY
WEST POINT

…clearly articulate learning objectives

Concept Summary:

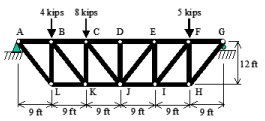
Learning objectives are statements that clearly articulate what the learner should be able to do after studying the reading assignment, attending the class, doing an assigned homework, etc. They must be measurable and help in lesson planning, guiding instruction, communicating expectations, and assessing learning.

Literature supporting the concept:

Wankat, P. and F. Oreovicz (1993)
Mager, R.F., and Peatt, N. (1997)
Anderson, L.W. et al. (2001)
Vos and DeGraaff (2004)
Alias, M. and Gray, D.E. (2005)
Baldizan, M.E. and McMullin, K.M. (2005)
Nilson, Linda B. (2010)
Svinicki and McKeachie (2011)
Marzano, Robert J. (2015)

Examples (MC300):

- List the assumptions used to analyze truss structures.
- Calculate the internal force in truss member AB.
- Design the members of the structural steel truss to withstand the loading shown in the diagram.



UNITED STATES MILITARY ACADEMY
WEST POINT

…utilize a variety of learning activities appropriate for the subject matter and level of the course

Concept Summary:

To appeal to a variety of students, enable the development of self-directed learning skills, and maintain interest and excitement throughout a course, a variety of learning activities is necessary. These activities should differ from course to course based on the subject matter and, importantly, based on the level of the course.

Literature supporting the concept:

Coffield, et al. (2004a&b)
Schraw, et al. (2006)
Prince (2004)

Examples:

- *All Courses*: collaborative learning activities; exercises requiring self assessment of understanding; require students to explain problem solving solution methods
- *Early Courses*: Increasingly complex problems; predict-observe-explain techniques; inquiry based learning exercises;
- *Senior Courses*: Open ended design problems which rely on information not covered in class; requiring students to teach other students

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…create rapport through positive interactions with their students

Concept Summary:

Rapport deals with the interpersonal phenomena that exist between an instructor and a student. Promoting positive emotions, such that the instructor respects the students as individuals and sees them as capable of performing well, has been shown to increase student motivation, enjoyment, and independent learning.

Literature supporting the concept:

Lowman, Joseph (1995)
Wilson and Taylor (2001)
Feldmann, Lloyd J. (2001)
Vogt, C.M. (2008)

Examples:

- Learn and know student names, interests, where they are from, etc. (student data sheets, interact before/after class, attend extracurricular events as OIC, OR, and/or spectator)
- Positive Communication; both verbal and non-verbal
- Exhibit Immediacy by being welcoming and approachable in conversations and interactions; being respectful; making time for AI; fair and objective grading; solicit and respond to feedback
- Opportunities for enhanced interaction exist in the form of capstones, laboratory experiences, and independent study courses.

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…carefully integrate technology to enhance learning

Concept Summary:

The tools that assist the teacher to teach and the learner to learn. Advances that help the student to learn on his or her own, help the teacher enhance the classroom presentation, and help the learner record notes and thoughts so that they can be used again for further reflection.

Literature supporting the concept:

Baepler, Walker, and Driessen (2014)
Estes, Welch, and Ressler (2005)
Educating Future Army Officers for a Changing World (2007)
deAquino, Allen, Lawton, and Withey (2016)
Garrison and Kanuka (2004)
National Academy of Engineering (2005)
Bransford, Brown, and Cocking (2004)

Examples:

- iPads for illustration of concepts during class
- iPads used in conjunction with online homework submission eliminates paper submissions and expedites the grading process
- Blackboard interface for information exchange
- Video AI
- Web-based laboratory prep videos

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…connect new to previous knowledge

Concept Summary:

The constructivist version of cognitive learning theory is the dominant interpretation in instructional design. In the constructivist interpretation, the learner builds new mental models on top of existing mental models. Instructors may assist the learning process by making explicit links between new concepts and those the students have previously learned and experienced. Increased connections between new and previous knowledge increases retention and recall which may contribute to deeper processing of the knowledge.

Literature supporting the concept:

Newstetter, W. C., & Svinicki, M. D. (2014)
Bransford, J. D., et al. (1999)

Examples:

- A student relates the concept of buoyancy to their selection of a larger fishing bobber when they added additional weight to a fishing rig after playing “will it float” in the classroom.
- A student relates the concept of a vibration node to hitting a baseball bat at it’s “sweet spot”.
- A student relates the idea of spring stiffness for a cantilever beam to axial bending analysis learned in their statics course.

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…are inspired for further inquiry

Concept Summary:

Inspiration: the process of being mentally stimulated to do or feel something, especially to do something creative.

Inspiration enhances a student's intrinsic motivation to learn, which encourages lifelong learning and more meaningful engagement with the course material.

Literature supporting the concept:

Knowles (1980)
Sheppard et al. (2010)

Examples:

- Encourage students to participate in extracurricular engineering activities and internships that expose them to real-world projects and build a social network
- Have students journal about their interest in the course and how it relates to their life
- Schedule student presentations on events, advanced technologies, or personal hobbies that relate to class material

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…take ownership of knowledge development

Concept Summary:

As cadets develop through the program, they become increasingly responsible for their learning. By doing so, they graduate as lifelong learners who are equipped to learn effectively in formal and informal ways.

Literature supporting the concept:

Knowles (1980)
Schraw, et al. (2006)

Examples:

- *All Courses*: collaborative learning activities; exercises requiring self assessment of understanding; require students to explain problem solving solution methods
- *Early Courses*: Increasingly complex problems; predict-observe-explain techniques; inquiry based learning exercises;
- *Senior Courses*: Open ended design problems which rely on information not covered in class; requiring students to teach other students

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...communicate effectively to a variety of audiences

Concept Summary:

Communication is:
the **means** with which a learner learns,
a **learning goal** in and of itself, and
a means for **demonstrating** the depth and quality of learning achieved (assessment).

Literature supporting the concept:

Male, et. al. (2010, 2011)
Dannels (2003)
Winsor (1996)
Johri, Olds (2014) Chapter 30
Pappas (2004)
Paretti (2008)
Shuman (2005)

Example: Written communication for assessment:

Lab reports, problem sets, and other graded written academic products demonstrate the learner's mastery in three areas:

- course content,
- written communication skill, and
- an understanding of how much effort it takes to produce high-quality, thorough, and professional-appearing written work, and an understanding that such quality is expected always.

If the course constraints allow it, revision of written work should be expected. Instructor or peer review should provide feedback about grammar, style, clarity, conciseness, thoroughness, and appropriateness for audience.

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...encourage collaborative learning

Concept Summary:

In collaborative learning, two or more people attempt to learn a concept together. This important learning tool can include asking each other for information, evaluating each others ideas, and others.

Literature supporting the concept:

Pritchard (2013)
Prince (2004)
Stevens, Johri, & O'Connor (2014)
Borrego, Karlin, McNair, & Beddoes (2013)

Examples:

- Junior faculty: have students work together to solve a problem in class that address low level learning: solving for an unknown in an equation, following a lab procedure.
- Senior faculty: have students work together to discuss ideas during class, or work together to solve open ended problems outside of class.

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…provide physical models, demonstrations, and hands-on learning opportunities

Concept Summary:

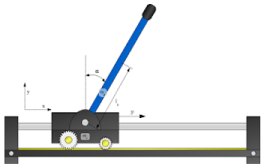
Depth of understanding of theory is promoted when the learner sees the meaning of the theory. Observing demonstrations and interacting hands-on with physical systems solidifies theoretical knowledge. Observing applications of theory can illuminate the *purpose* of the theory. Learners can see also how assumptions limit the range of application of theoretical models.

Literature supporting active learning:

Prince, (2004)
Freeman, et al. (2014)

Example: Inverted Pendulum-on-Cart Balance Control

An inverted pendulum on a cart is an unstable system, but it can be stabilized by controlling the position of the cart. Designing an automatic balancing control requires a sufficiently deep understanding of theory *and* an ability to work hands-on with mechanical and electrical systems. When learners successfully implement a control, they have developed deeper understanding than they would by theory alone.



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…provide opportunities to practice and apply new knowledge

Concept Summary:

Rote learning is one of the oldest and most basic learning ideas: practice makes perfect. In the learning environment, practicing knew knowledge can help induce deep learning and create a strong foundation on which to build.

Literature supporting the concept:

Skinner (2011)
McSweeney and Murphy (2014)

Examples:

- Junior faculty: Taking boards, homework problems, and classroom assignments.
- Senior faculty: Writing assignments with review/revise cycles.
- New knowledge can be practiced and assessed, without being evaluated.

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…foster problem- scoping and -solving skill development

Concept Summary:

Challenge and enable students to:
- *Define a problem (given a situation)*
- *Determine criteria for completion/success*
- *Identify relevant physical concepts*
- *Identify and apply assumptions*
- *Deal with ambiguity*
- *Identify and harness resources*
- *Develop means to check the results*

Literature supporting the concept:

Kurfiss, J. G. (1988)
NAE (2004)
ASEE TUEE (2013)

Examples:

- Capstone and Independent study experiences
- Real-world case studies or design challenges as class projects
- "Mix in" questions from previous lessons so solution approach is not obvious (most recent material covered in class)
- Instructor provides too much or too little information to solve a problem
- "What size wing(s) would you need to make a minivan fly?" MC312 homework question

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…student learning (by the instructor and by students)

Concept Summary:

Never be satisfied! Instructors should continuously seek to answer *how well are my students learning?* An ideal assessment plan should offer a means of gauging the effectiveness of both presentation (by the instructor) and reception (by the students) of learning objectives. Assessment should be frequent, timely, and come in varied form. Consider forms of both normative (graded) and non-normative assessment. As learning is a partnership between instructor and student, seek to incorporate means of student self and peer assessment into your overall plan.

Literature supporting the concept:

Flavell (1973)
Angelo and Cross (1993)
Black and William (1998)
Estes, et al. (2006)
Spurlin, et al. (2008)

Examples:

- Graded events (WPR, Writ, Problem Set, Lab Report, EDP)
- Self reflection (having students quantify confidence in solution as part of problem set
- Peer review of graded work prior to submission
- Mid-course surveys (muddiest point, etc)

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...the classroom environment

Concept Summary:

Environment is often just as important is as content and presentation. Instructors should continuously assess whether they have structured their classroom environment in way that maximizes student learning. They should understand that this environment extends well beyond the walls of both their physical virtual classrooms. The course schedule, communication mechanisms, pace, collaborative climate, and instructor access all contribute to the overall learning environment.

Literature supporting the concept:

Flavell (1973)
Angelo and Cross (1993)
Black and William (1998)
Estes, et al. (2006)
Spurlin, et al. (2008)

Examples:

- Seek student input to shape the environment (Identify how they prefer to communicate, etc)
- Encourage students to contribute interest material
- Continuously identify and address distractions