Applying the Plan-Do-Check-Act Cycle to Develop Best Practices in Remote Online Systems Engineering Education

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Abstract. Systems engineering educators are inherently challenged to provide effective education to industry and government practitioners. Separating instructors and students by time and location, as is the case in remote online education, compounds the challenge. This paper summarizes research on the impact of the use of various pedagogical approaches on the effectiveness of teaching systems engineering in a remote online environment. Using that research as a leverage point, the Plan-Do-Check-Act (PDCA) cycle is presented as a viable process for developing best practices for remote online systems engineering education.

Introduction

Nearly half a century ago, the Carnegie Institute of Technology announced a new doctorate in the systems and communication sciences in 1962 that would "…provide preparation for research and university teaching in an interdisciplinary field concerned with the organization of complex systems…" (Reitman, 1962, p. 119) Since that announcement, systems focused curriculum, in the form of systems engineering education, has continued to extend its reach across a broad set of disciplines faced with the need to understand and work with systems. Sage (1979) recommended integrating systems engineering with electrical engineering education "…towards achievement of appreciation of the vital role of the human element in resolution of the large-scale problems through technology." (p. 81) Brown and Scherer (2000) suggested that universities recognize the opportunity for growth in systems engineering education; otherwise, "if the academic institutions do not respond to …these opportunities, then systems engineering will remain a footnote among the engineering disciplines…" (p. 212). Furthermore, if the engineering schools did not address the growing need for systems engineering education, Brown and Scherer (2000) suggested that "…the needs will be met by business schools and others who are more eager to respond to the needs of industry and government." (p. 212)

Today, systems engineering education and training is addressed through a variety of methods not only through university programs which continue to be on the rise but also through private consulting and in-house training. In 2010, Fabrycky identified 80 institutions in the United States that offered a total of 165 systems engineering education-focused programs divided into Systems Centric Systems Engineering (SCSE) programs – "…where SE is the intended major area of study." (p. 5), and Domain Centric Systems Engineering (DCSE) programs – "…naming Systems Engineering within a parent engineering domain." (p. 5)

Squires & Cloutier (2010) identified 18 systems engineering focused graduate programs that were offered by 17 domestic institutions through an online format to remote students; at least

two universities have joined since, bringing the total up to 19 domestic universities (Squires, 2011). Clearly, the call for addressing systems engineering education through the academic institutions has been heard and responded to, and yet the critical need for systems engineering education and training is still being felt across industry and government.

Remote online education offers a method by which systems engineering education can be offered to those who are not local and are not able to travel (time or funding constraints) or to those who are simply looking for ways to balance quality of life while getting the education and training needed to excel on the job. However, research in remote online systems engineering education is limited. Systems engineering educators typically deploy seemingly common sense methods when moving to the online format, without the experience or lessons learned to completely understand the impact of their chosen approach. This paper leverages both experience and research specific to delivering systems engineering curriculum through the remote online format and offers a Plan-Do-Check-Act (PDCA) cycle for developing best practices, as guidance for those interested in excelling in remote online systems engineering instruction.

Background

The plan-do-check-act (PDCA) cycle, described by Deming in his 1982 book *Out of Crisis*, has been adopted by countless organizations across a wide variety of business domains in the pursuit of continuous improvement of business processes. The use of the PDCA cycle has evolved over time from a process in support of statistical control, into a problem solving approach as shown in Table 1 (Mildram, Spector & Treger, 1999; Revelle, 2004).

Table 1: PDCA as a Problem Solving Approach

Mildram, Spector and Treger (1999)	Revelle (2004)
Plan Stage: First step in identifying the primary problem, results in an action plan developed by an individual or team that has analyzed the problem.	**Plan:** Step for planning how a change or improvement will be achieved. Involves identifying an area of opportunity and forming a team to collect and analyze pertinent data on the process.
Do Stage: The action plan is implemented on a trial basis.	**Do:** The change or improvement is implemented on a small scale.
Check Stage: The results are analyzed, statistical techniques can be used, to assess if the cause of the problem has been addressed.	**Check/Study**: Measured results are compared against the plan goals to determine level of success and next action.
Act Stage: The action plan is modified as needed based on the 'trial' results. Results are continually monitored.	**Act:** Take corrective action if needed before making change on a more global scale, continue to evaluate for new change or improvement.

Developing Best Practices Using PDCA

While there are many best practices documented for distance education, the best practices addressed in this paper pertain particularly to experiences and research focused on systems engineering and related courses offered in the remote online environment. By applying a systems perspective and presenting these best practices as part of a plan-do-check-act cycle, the hope is to communicate these best practices in a way that is attractive to systems engineers and current and potential systems engineering educators. Figure 1 summarizes the PDCA steps

for developing best practices that are described in more detail in the remainder of the paper.

Figure 1. PDCA Cycle for Remote Online SE Education

Plan

The 'plan' cycle addresses the identification of a problem or opportunity. As part of this cycle, best practices can be identified in these areas:

- Understand the System Context
- Address Requirements from Beginning to End
- Consult Subject Matter Experts (SMEs)

Each of these is further explained in the following sections.

Understand the System Context. The need to understand the system context is no different when considering the educational system being leveraged as it is for any other type of system being applied in a new or perhaps even unproven context. The environment for remote online systems engineering education is vastly different in many respects than the environment for traditional classroom training. For example, while both environments have the opportunity to leverage technology to deliver content; the use of technology is optional in the traditional classroom but required in the remote online environment. Squires & Pennotti (2007) identified a top-level architecture for the remote online classroom. This architecture is based on Moore's (1989) three types of interaction: learner-content, learner-instructor, and learner-learner; and Hillman, Willis, and Gunawardena's (1994) fourth type of interaction: learner-interface. An updated representation of the Squires & Pennotti (2007) architecture developed in Squires

(2011) is shown in Figure 2.

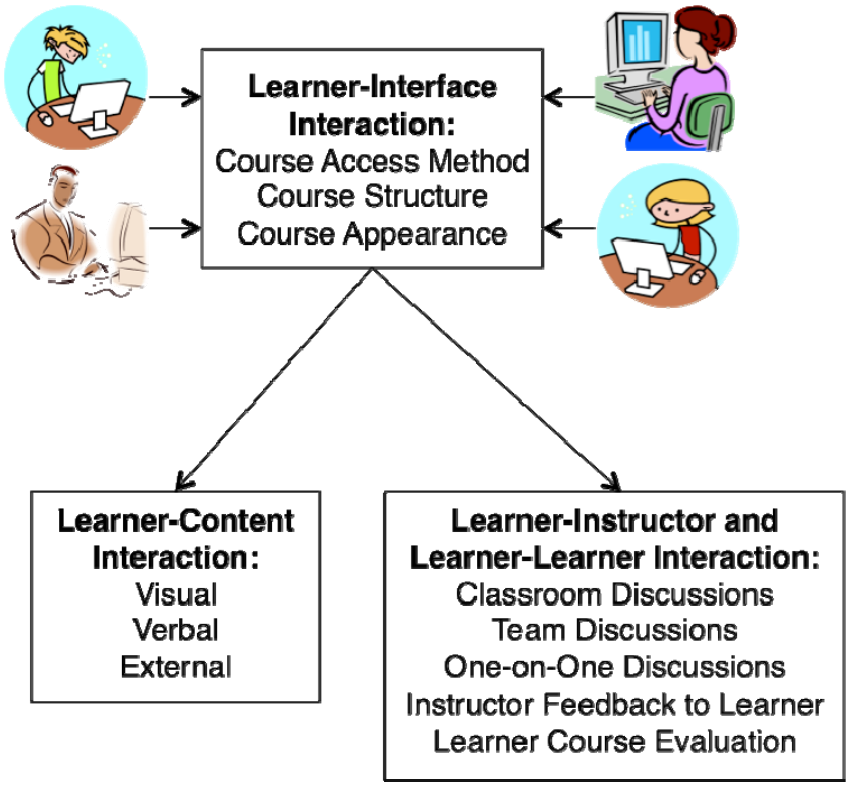


Figure 2. Remote Online Classroom Architecture (Squires, 2011)

As shown in Figure 2, the learner interface – consisting of the appearance, structure and methods used to access the course – typically represents the first exposure the learner has to the remote online educational experience. These first impressions are lasting and can affect the student's approach and motivation for learning the content presented. For these reasons, instructors should understand how to use technology to best present the systems engineering curriculum to the student within the technology available. This will require the instructor to undergo training either offered by the academic institution or the application vendor on the use of the technology. Instructors need to take advantage of this training to the extent possible, especially if it is the instructor's first time teaching remotely online. In the worst case, an instructor that does not understand how to use the technology will cause unnecessary confusion for the students who may not be able to access assignments or other course content that have not been posted properly. In the best case, an instructor can create an engaging online atmosphere that keeps that students coming back for more.

Use of various types of multimedia including audio and video podcasts and providing related links to high quality fair use content are some best practices in this area. For example, Squires, et. al. (2006) evaluated a series of seven remote online course deliveries for a condensed version of a semester long Fundamentals of Systems Engineering course that took place over a two-year period. In this case study the impact of audio lectures (or lack thereof) on student satisfaction and learning was evaluated. The findings were based on course evaluation survey feedback from 131 students. From these findings it was evident that the courses that contained the pre-recorded audio lectures related to an increase in student satisfaction with both the course and the instructor; however, there was not a discernable difference demonstrated in student performance in the final course project.

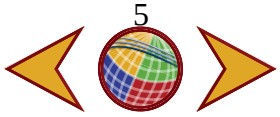
Another focus can be minimizing the learning curve of the student in how to use the learning system in order to maximize the student's ability to focus on learning the systems engineering content. One best practice used in the School of Systems and Enterprises has been the establishment of a common look and feel from course to course, and a common navigation scheme for accessing the course content for each online course to minimize the student's initial learning curve to 'find' their way around at the beginning of each new online course.

A third focus might address the impact of the absence of face-to-face contact in the remote online environment (for related discussion, see "Address Isolation"). We take for granted the impromptu interactions that take in a traditional classroom; these will not happen in the remote online environment. Do you typically provide a short demo in the classroom to explain a complicated but easily demonstrated concept? Do you provide informal feedback to the students about assignments or content that is key to their performance and learning in the class? These impromptu or informal interactions need to be identified and alternative means established for addressing how to achieve similar outcomes in the remote online class.

Address Requirements from Beginning to End. Understanding the requirements that need to be considered over the entire semester are only a subset of the requirements of the course over its life cycle; however, these are the requirements (semester-based) being considered in this section. Instructors in traditional on campus semester courses have the ability to work on each week's lesson in real-time prior to the start of that week's session. In the remote online environment; however, there is a need to provide the documentation of the course material for the entire semester as early as possible, preferably at the start of the course. This is true even when weekly web conferencing sessions are held for lecture delivery and course content discussion. The actual material to be presented and all related course assignments should be available for student access at the start of the course. This allows the instructor more time to focus on working with the students during the semester through web conferences, phone conferences, e-mail or online text chats rather than having to spend time to 'open' or 'close' discussions, assignments, or other content in a timely manner. Having the complete course content available, to the extent feasible, also allows students to access the material ahead of time if needed due to business or travel commitments. However, the development of totally new course content may be better addressed over the timeframe of the semester so that adequate time is available to create high quality material, especially if the online semesters continue back-to-back throughout the year. New material should be modularized to the extent possible so that the majority of the existing content can be made available at the start of the class and the new material added by the appropriate time in the semester. Newly developed content can then be merged with existing content in the next iteration of the remote online course, where the same approach to curriculum update begins again.

Another best practice is to develop and build upon a frequently asked question (FAQ) list. A list should be made available for each week of the course and should address commonly asked questions on assignments and course content. If this is the first time the course is being taught online, frequently asked questions can be collected or developed based on the traditional delivery of the class and used as a launching point for the online section. New questions will emerge in the online delivery and these should be evaluated for inclusion in the FAQ list for future offerings of the course.

Consult Subject Matter Experts (SMEs). As with any systems project, the experienced systems engineer knows when it's time to bring in a subject matter expert (SME). It is easy for



an instructor to believe that a common sense approach will work when setting up their online course. However, the remote online environment is an extremely challenging venue to work in from an educational perspective. Online students have different expectations than traditional classroom students. The technology is unfamiliar. Expectations are not as well understood all around. Skills that have served the instructor well in the traditional classroom may be a hindrance in the online classroom, and areas of strength or weakness as an educator may be compounded in the new environment.

Take the simple example of communication. In a classroom, an instructor is normally the focal point of a lively in-class discussion related to some topic of the course content. If the instructor were to stop participating in the discussion, it's likely the students would as well. That is, if the instructor turned and started a different activity the class would likely turn their attention to something else as well. If the instructor never participated in the classroom discussions, the students would be disappointed and in general dissatisfied. However, in the online venue, discussions kicked off with a question by the instructor can result in engaging lively discussions that the instructor never actually contributes to in a visible way (read but not replied to). Student's satisfaction with the learning experience in this case has been shown to be nearly equivalent to discussion in which the instructor participates (Squires & Cloutier, 2010a).

A best practice, however, is to clearly set the expectations for the discussion at the beginning of the course. Feedback from the instructor related to the discussions should still be visible on the same basis as the discussions are held, that is, if discussions are held weekly, the instructor should provide grades and feedback related to the discussions weekly. This supports the positive correlation found by Squires & Pennotti (2007) between the frequency and detail of instructor feedback and the level of student satisfaction with the course and the instructor. These and other related findings and experiences may go against one's initial or common sense assumptions and this is why it is important to seek out subject matter experts on distance education before taking the leap.

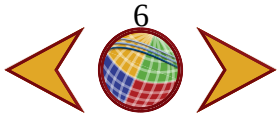
Do

The 'do' cycle suggests implementing an action plan on a trial basis or small scale, and everything is typically on a small scale when we are referring to one or two sections of an online course in one semester. As part of this cycle, best practices can be identified in these areas:

- Experiment with the Schedule
- Right Size the System
- Address Multiple Learning Perspectives
- Establish Strong Relationships

Each of these is further explained in the following sections.

Experiment with the Schedule. A recommended practice in the online venue is to be flexible with specific timeframes for work to be completed. Instructors should factor in the student's need to balance availability by allowing students to work ahead as feasible and extending the time or creating flexible start and stop times for completing timed assignments or open book work-at-home examinations. Finding the right timeframe and acceptable level of flexibility may take some experimentation. Weekly or bi-weekly (every other week) due dates require some investigation and experimentation depending on the extent of the assignment, student



procrastination, and the availability of the instructor to give prompt feedback. For example, several core courses in the systems engineering program at Stevens Institute of Technology had weekly assignment due on Thursday midnight. This meant that the instructor was working weekends to complete the feedback within 72 hours, and this went on for semester after semester for several consecutive years, resulting in instructor burn out (and no weekends off for the foreseeable future). The students tended to have as much difficulty with the Thursday due date as the instructor had with the providing feedback by Sunday. The students did not have the feedback until the weekend was over, and the weekend was their prime time for getting together on the next week's project. Once the assignment due date was changed to Sunday at midnight, the situation vastly improved for both the instructors and the students. Jackson & Jackson (2009) investigated the relationship between assignment due dates and students needs. They received responses from 337 graduate and undergraduate students who were taking at least one online course and the overwhelming response was that online students prefer assignments to be due "directly following a full weekend". (Jackson & Jackson, p. 1) In this case the actual research results validated the earlier change made, through trial and error.

Right Size the System. The ideal size of the class is quite dependent on the type of activities in the course including the format of the discussions, the type of assignments (team or individual) and even the topic being covered. For a course covering a complex topic with weekly online discussions and team assignments, experience indicates that 25 is too many for the online class; 20 is a good compromise; but 16 is ideal. Too many students make the online discussions overly cumbersome, not enough students may lead to repetitive or less interesting discussion threads. For team sizes, a team of four team members seems to work well in most cases; five members are too many and hides 'slackers', and three members may not be quite enough to accomplish the work needed. As with the class size, the ideal team size will depend on the type and scope of the team assignments.

Address Multiple Learning Perspectives. Theories on preferred learning styles such as Felder-Soloman learning styles inventory or Kolb's learning theory, relate as equally to online learning as they do to learning in the traditional classroom. For example, some students are primarily visual learners and some students are primarily verbal learners (Felder & Soloman); some students learn better by reflecting, others by doing (Kolb, 1984). As previously mentioned, Squires, et. al. (2006) evaluated a series of seven remote online course deliveries and evaluated the impact of audio lectures (or lack thereof) on student satisfaction and learning. The findings indicated that the courses that contained the pre-recorded audio lectures where the students had access to slides, audio, and written speaker notes of the audio, related to an increase in student satisfaction with both the course and the instructor; however, there was not a discernable difference demonstrated in student performance in the final course project. Further work by Squires (2011) investigated online pedagogy and student satisfaction and learning. The lecture delivery approaches evaluated ranged from posted lecture slides, to written, audio-recorded, and real-time lectures. The approaches evaluated for content discussions included text and/or audio-based discussions that were either student or instructor led with or without consistent instructor participation. Squires (2011) found that the use of multiple approaches to deliver lectures and hold content discussions in online courses was related to both increased student satisfaction with the learning experience, and an increase in student perceived learning of systems engineering competencies.

Establish Strong Relationships. Student isolation is especially an issue in the online environment. One way to address student isolation is to hold a real-time 'kickoff' meeting (that is also recorded) at the start of the course to relay instructor expectations and respond to student

questions; and to begin to establish instructor and student relationships. One practice commonly used by Stevens Webcampus is the posting of instructor and student profiles that allow the sharing of work, school, and personal information, as desired. These profiles can also include student availability that can be used to help the students form teams where members have common availability. Teams also appreciate a private team discussion area or chat board, including the option to have their own 'room' for live web conferencing meetings, if possible. Meeting rooms that include the ability to record and archive the meetings for team members who may not be able to attend in real-time, is an added bonus.

Class discussion is another way to address isolation in the online classroom. Squires & Cloutier (2010a) looked specifically at the impact of classroom discussions on student satisfaction where classroom discussion could take place through different venues such as real-time web conferencing or online synchronous (real-time) or asynchronous text based, and at various frequencies such as weekly, every other week, a few times during the course, or never. Thirty-two instantiations of twenty-two courses were included in the population of the study and 445 of 485 possible student course evaluations were returned and used for the analysis. The findings indicated that the use of classroom discussions in the remote online environment was related to student satisfaction; however, this was true regardless of whether the instructor actively participated in those discussions or whether students were the only active participants.

Frequent faculty feedback helps to address student isolation. Leveraging the remote online course architecture shown in Figure 2, twenty-two architectural components were identified and evaluated by Squires & Pennotti (2007) as to the impact of each architectural component on student satisfaction and learning. Thirty-seven instantiations of twelve courses were included in the population of the study and analyzed for which components applied for each course instantiation, and 379 of 438 possible student course evaluations were returned and used for the analysis. Findings indicated that of all the course components, it was the frequency and detail of faculty feedback that showed the strongest correlation to student satisfaction with the instructor of the course. The only higher correlation with this particular component was the peripheral finding that those students who received the most frequent and detailed feedback from the instructor were also more likely to complete the optional course evaluation when requested by the instructor.

Another method for the instructor to directly address isolation is to send private notes to students. These notes can be sent based on an especially insightful discussion comment, or to follow-up on something unique or unusual that the student included as part of an assignment, or based on other positive follow-up comments from the course. Keep a temporary tally to be sure to send at least one private note to each student a few times during the course to help the students feel less isolated. These notes open the door to students sharing more about any concepts they may be struggling with or providing the instructor specific feedback on how the course is going for them, etc. In the online classroom, instructors need to remind their students that questions, comments, and suggestions are always welcome. In general, instructors should make an effort to help the students feel as if they 'belong', which is especially important, albeit challenging, in the online environment.

Check

The 'check' cycle is where one observes the outcome of the 'experiment' implemented in the 'do' cycle. As part of this cycle, best practices can be identified in these areas:

- Define and Evaluate Success Criteria

- Seek True Cause and Effect
- Take In-Performance Measures
- Keep the Situation in Perspective

Each of these is further explained in the following sections.

Define and Evaluate Success Criteria. To define success criteria consider factors that are important to you, your students, and your university. Use these definitions to guide you in measuring how the outcomes you observed from your 'experiments' compare. For example, from a student perspective, students consistently agree that prompt feedback is an important criterion for both satisfaction with the learning experience and also for improved student performance in the class. In this particular context (see Understand the System Context), the typical student seeks some level of acknowledgement that they are on the right track. In a traditional classroom, the student who requires a high level of feedback may be more proactive in the class in seeking feedback, may stay after if they have burning concerns, or visit the instructors during his/her office hours, or send the instructor e-mails (as a last resort!). In the online venue, there can be an issue of students expecting instructors to be available 24x7. The instructor can set office hours, stating availability either by phone or instant message, but the reality is that students are taking online classes to balance a hectic lifestyle and having to attend a specific – in some cases viewed as restrictive – timeframe each week to ask general questions is not typically desirable; yet instructor disappointment sets in when no one shows up. In the end, having office hours in the online environment for establishing times that the student can call or instant message the instructor without an appointment is only one part of a multi-step approach. Giving the students options for setting up meeting times, having instant messaging capability when you are online, responding to e-mails within 24 hours or same day (depending on when the e-mail is sent), and other options, offer more workable alternatives.

Seek True Cause and Effect. Relationships between cause and effect are not easily discerned in the remote online environment. This is because, as in any class experience, each time the content is taught the experience will be different both from the perspective of the instructors as well as from the perspectives of the students. That is, the same systems engineering course taught by the same instructor during the same semester with the same course structure, interface, content and approach, but to a different set of remote online students, can yield different results in student satisfaction and performance. This difference in results is not only due to the different student set but also due to differences in the experiences of the students and the instructors between the separate sections of the same course. These differences can be due to timing differences in the feedback, differences in the direction and focus of the discussions, or other factors. One best practice when teaching multiple sections at a time is to take turns on which course takes priority – that is, which course the instructor logs into first, answers the questions for, participates in the discussions, etc... Even when only one course is taught it is important to take turns on which individuals or teams get their feedback first and/or last. To understand true cause and effect, a rigorous statistical analysis can help. Barring that, conclusions or ideas on cause and effect should be suspended, or at least put on probation, until more experience is gained in the remote online environment. As the saying goes "Good judgment comes from experience, and experience comes from bad judgment."

Take In-Performance Measures. Several methods exist to collect the type of technical performance measures (TPMs) that are often used to gauge whether a project is on track or not. First, there are self and team assessments. Especially when students are working in teams, it is important to ask the student to assess their individual performance on the team, and the

performance of the team members. This assessment needs to occur midway in the cycle as well as towards the end of the course, but it's the midway collection of this data that is more important for steering the group in the right direction. One issue with teams is 'the slacker'. This is true in any learning environment but is more difficult to address in the remote online environment, especially if not addressed early in the course. A best practice is to clearly establish the policy that every member of the team earns the same grade based on the quality of the product delivered, just as on the job; however, if a specific student is participating at a lower level, that student can earn a lower grade. This addresses two issues: first the quality of the final product. Many times when a slacker is on the team, the other members use that as an excuse to hand in a lower quality product. This policy makes it clear that the team will earn a lower grade. Second, the individual students should not have to handle a slacker on their own. By establishing the policy by which the slacker will earn a lower grade, this typically puts an end to the slacking. There are exceptions, but this policy generally works. Other approaches include developing discussion questions (questions posted to students for their reply each week) that address course content but also include aspects of what is working well in learning or understanding the systems engineering concepts, and what is not working as well.

Keep the Situation in Perspective. As Niels Bohr says: "There are trivial truths and the great truths. The opposite of a trivial truth is plainly false. The opposite of a great truth is also true." In the same spirit of Neils Bohr's statement related to holding two conflicting ideas at the same time (and living through it!), a best practice is to balance appropriately between 'Don't take student feedback personally' and 'Take student feedback personally'. On the one hand, there are some students who are not comfortable with online education and there is a high hurdle of acceptance that the instructor may or may not be able to guide the student through. In that case it is recommended not to take the student's feedback personally as there may not be much one can do to correct the situation within reason. On the other hand, when multiple students are expressing the same issue with the course in general or the instructor specifically, there is probably an action that needs to take place, either in the 'do' or 'act' phase of the cycle.

Act

The 'act' cycle results in the implementation of a more comprehensive action plan that addresses the results of the 'trial' performed previously. As part of this cycle, best practices can be identified in these areas:

- Focus on the Long Term
- Apply Multiple Views
- Stay Current on Technology and Leading Edge Practices
- Adapt to the System Behavior

Each of these is further explained in the following sections.

Focus on the Long Term. Once you have taught your first online course the first decision you have to make is 'do I want to do this again?'. In his 2007 study, Peter Shea surveyed 386 higher education faculty that taught courses online across 36 colleges that were part of a large state university. He found that for those teaching online: "The top motivator is a more flexible work schedule. The top demotivator is inadequate compensation for perceived greater work than for traditionally delivered courses, especially for online course development, revision, and teaching." (Shea, 2007, p. 73). Inadequate mentoring is also a demotivator especially for inexperienced online faculty. Green (2009) suggests that training be provided for all levels of experience and that veteran instructors should serve as mentors for beginning online

instructors. There is no question that for beginning instructors, teaching an online course can be intimidating and overwhelming and the time commitment is far more than originally anticipated. However, with time, experience, an open mind, and a good set of best practices, the motivators begin to outweigh the demotivators. Convenience, flexible schedules, and freedom to travel, some of the same attractors for remote students, are also incentives for online instructors to continue, especially if they hope to continue teaching after retirement but want to have the freedom to travel.

Apply Multiple Views. When focusing on a long-term action plan, consider the perspectives of future instructors, the students, the administration, and the institution. Also consider the wide variety of delivery formats that are being, or will be used, to deliver the systems engineering course content being developed. Other considerations include not only a full spectrum of pedagogical approaches but also the full range of technology available to be leveraged (see next section!). As an example, when preparing a lecture for the remote online course, consider recording a live real-time lecture being delivered as part of a face-to-face course, on the same topic. This can be a timesaving approach and also offers a more realistic version of the lecture than perhaps a pre-recorded lecture. Use technology that will create a recording that is editable (to remove dead space or unrelated side conversations) and consider how that will impact both the students in the classroom at the time, and other students in the course who may not be able to be present or future students in future courses. One best practice is to use the 'best of the best' lectures recorded by experts through a collaborative effort. These recordings can then be used in any type of course delivery; traditional, online, or a hybrid.

Stay Current on Technology and Leading Edge Practices. The majority of systems engineering students today are digital natives. While the average student age may be somewhere in the mid 30's, the actual age of the system engineering student is a spectrum that is highest in the under 30 group, at a midpoint across the over 40 crowd, and in a slump between 30 and 40, typically. Digital natives expect and even demand that their instructors and mentors have the ability to leverage technology effectively. Seek additional education and training through the university, online, and from application vendors that service the university. Stay tuned to the technology being used by the students. Consider making lectures and content available through mobile devices.

Adapt to the System Behavior. Especially in the beginning stages, instructors will find that teaching systems engineering in the remote online environment does not provide the outcomes expected. While it may be easy to decide that undesirable outcomes are caused by the technology, student behavior, or other external uncontrollable factors; alternative approaches that the instructor does have control over should be sought and tried, in order to address unexpected system behavior. This of course leads back to the beginning of the PDCA cycle. As an example, if most of the submitted weekly assignments indicate that the lesson objective for that week was not achieved; the suggestion is to redo the lesson from another tact, and allow the students to redo the assignment. As instructors we may take for granted that what has worked successfully in the past in a traditional classroom will work in the remote online classroom. Our experience has shown that this is not always the case. In the online environment, instructors typically cannot see that the students are not understanding the material or are struggling with a particular concept and so instructors are not able to focus in that area that needs special attention in the course for that particular student set.

Summary

The most important action the systems engineering educator can take in the remote online

environment, is to be clear about expectations in all the areas covered in this paper. For example, instructors should let the students know when and how they should be contacted. Instructors should provide the students with timely feedback even if that consists of a short note or a general weekly announcement. Best practices include being proactive in viewing the situation from multiple perspectives; staying current with technology; and focusing on the long term view.

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