International Conference on Communication, Management and Information Technology (ICCMIT 2015)

Distance learning and the control theory metaphor

Pascal Roubides*

*Broward College Online, Ft. Lauderdale, FL, 33301, United States

Abstract

This monogram offers an empirical discussion of a common issue appearing in the design of eLearning courses nowadays and the even more commonly found misperception of many faculty about delivering such courses. These issues are viewed from the perspective of an engineer designing a mechanical control system, the design of which can affect the mechanical output or behaviour of the system resulting in different outputs based on the existence and proper use of its various components. Courses designed for online delivery, just like mechanical systems, require input, controllers and regulators, and a sought-after output. The components of online courses form a dynamical eLearning system in which, similarly to its mechanical counterparts, the mere presence of the components themselves cannot result in an optimally controlled system without the presence of necessary and appropriate controllers. This critical review of the topic identifies the current realities and drawbacks and offers an innovative view in the context of distance learning systems and their impact.

Keywords: eLearning; online course design; dynamical eLearning system; instructional design.

1. Introduction

Multiple studies have been done over the years in the education space and more recently in the online education space (eLearning), its merits, shortcomings, and most of the ins and outs of what makes online education a viable (or non-viable) learning enterprise and experience. Roubides1 presented a literary review on the current state of eLearning, including statistics that showed the increasing popularity of this mode of education among several different types of populations throughout the globe and examined perceptions surrounding eLearning both from faculty and student...

* Corresponding author. Tel.: +1-954-201-7900.
E-mail address: proubide@broward.edu

1877-0509 © 2015 The Authors. Published by Elsevier B.V. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).
Peer-review under responsibility of Universal Society for Applied Research
doi:10.1016/j.procs.2015.09.077
points of view. In the ensuing decade, much has changed in the online arena; nevertheless, the underlying principles have remained the same. In this monogram, the author raises an important issue regarding the design of courses developed for online delivery and the role of faculty in eLearning by using an unlikely metaphor from the field of engineering.

2. The facilitator model

As educational institutions have started developing or adopting eLearning programs in the past decade, the role of faculty in this new environment had to be redesigned, redeveloped or re-invented in order for the faculty contribution to student learning to be equally effective as in the traditional face-to-face environment. Early research in this field spanning the past two decades has been supportive of this notion (see for example Beaudoin\(^2\) and Paulson\(^3\)). Furthermore, it has also been recognized that it is usually not only the introduction of technology that drives learning in this new environment but also the effectiveness of the teaching style and the technique of instruction used (Berge\(^4\), Jones, Lindner, Murphy, and Dooley\(^5\), Lindner, Murphy, and Dooley\(^6\), Paulson\(^3\)).

The model of facilitation as a popular type of online instruction presented by Roubides\(^7\) is one of many possible approaches. The foundations for these ideas form a basis of understanding of a working facilitation model in the field of instruction and individual experiences with the process of facilitation as participant, enabler, and facilitator of online classes.

Facilitation of online classes, much like judicial mediation among litigating parties, is an ever-evolving art and expanding opportunity to empower groups to work together across time and distance. Online activities, communications and interactions require facilitation skills beyond those used in face-to-face settings. Group dynamics in the virtual environment combined with new eLearning standards or technologies, such as what is commonly referred to nowadays as Web 2.0 tools, create unique conditions and opportunities calling for specific techniques that may be totally dissimilar to those employed in traditional face-to-face (especially instructor-centered) settings. Counter to the practice of lecturing, which implies passive receipt of instruction, online facilitation supports an active learning environment based on a student-centered philosophy, as proposed by O’Neil, Moore, and McMullin\(^8\), and implies a process where there is engagement of everyone present in the class. In this model, the facilitator becomes essentially a learning manager, a person whose main responsibility is to promote the learning process but at the same time provide guidance to and control for and of the learner

3. The control theory metaphor

Simrock\(^9\) explained that in engineering, control theory deals with the behaviour of dynamical systems. It involves controlling physical parameters such as the temperature of a room, the pressure of a vessel, the flight of an unmanned space vehicle, and in general the operation and performance parameters of machines. A simple example in everyone's knowledge is the cruise control in a vehicle, a system that automatically controls the speed of the vehicle as set by the driver.

Regardless of the type of system, each of these systems must be controlled to predetermined or predefined performance criteria or specifications. This can be accomplished by obtaining measurements and using the information obtained for feedback to adjust the controlled variable to the desired level. When one or more output variables of a system need to follow a certain reference over time, a controller or regulator manipulates the inputs to the system in order to obtain the desired effect on its output. In the example of a cruise control device in a vehicle, the controller senses any deviations in the vehicle's speed from the pre-set value and adjusts other vehicle systems accordingly (such as the throttle or braking systems, thus allowing the speeding-up or slowing-down of the vehicle).
A diagram of a simple engineering control system concept along with its basic components is shown in Figure 1; the system must have an initial input aiming at achieving or maintaining a certain characteristic or variable in the plant (the component of the system to be controlled) whose response in turn triggers a sensor that routes data back to the input that can be adjusted to compensate for a satisfactory characteristic sought for in the plant.

The design of controllers for such systems are easier to accomplish for engineering students and professionals who have completed undergraduate or graduate-level courses or training in Control Theory than, say, a history professor with a Master's or a Doctorate degree in his/her field offering a World History course online. However, not unlike an engineer using a controller to manipulate or maintain the designated characteristic in a machine, faculty engaged in online courses in any field are also tasked with managing and/or maintaining predetermined levels of accomplishment of learning objectives by the students through effective use of available tools.

An online course can be considered to be a technical system, similar to the control system described above. Moreover, in all sciences, such as biology, physics, engineering, as well as the social and cognitive sciences, the concept of a system is used to describe a group of interacting components connected through a variety of distinct processes according to Heisenberg. Therefore, all components of an online course should be considered inter-related and inter-connected components of the same active system.

In this sense, faculty, students, learning material, and the technology that connects them all are components of the same system that are inter-related and inter-connected by a number of distinct processes. Faculty provide the initial system input through learning material created to achieve predetermined learning objectives at predetermined levels of accomplishment (the system variables to be manipulated). Students (the plant) have a certain output (learning achievement/performance) based on the given input which is determined by assessments (the sensor) designed and provided by the faculty. Based on the initial output, new or adjusted input may be (and usually is) necessary in order to manipulate, change, or maintain the level of achievement displayed.

4. Faculty as instructional designers

Since the creation of the Open University in the United Kingdom, which established a practice of separating course development from course delivery, traditional institutions of higher learning delving into the online education arena have been caught in the middle. In the Open University model, teams of content specialists and educational designers jointly develop each online course, which is then delivered by faculty who may or may not have had any exposure to the online environment and are now filling the role of eLearning delivery experts.

According to Edelson that has not been the way things have been done traditionally in the United States. In the U.S., higher education (at least at state-supported institutions) is constructed at the classroom level, whether traditional or virtual. Despite being a multibillion dollar enterprise, the US education model is at heart a cottage industry with individual faculty developing, delivering, and even evaluating their own courses. Though the recent trend attempts to change this traditional model by adding a new category of academic personnel under the title of instructional designers, the main function of these professionals is to help orient faculty to the electronic environment and only assist faculty with certain aspects of course development.

In that respect, faculty are also, to a certain extent, instructional designers themselves. Pappas provides a short and concise account of what instructional designers really do as opposed to what they are thought to do and by
inference, this also applies to faculty engaging in online instruction. In most cases, whether performed by instructional designers, course developers, or faculty themselves, the main focus on the creation of an online course falls on being able to provide ample input via a lot of different types of materials in an attempt to address as many learning styles as possible, and using a multitude of technological tools as if the mere existence of all of this would induce the expected outcome. Many researchers over the last decade (see for example Roubides\(^1\), Nguyen and Klein\(^13\), and Musgrove and Thirlaway\(^14\)) have argued that the above mentioned statement is only true if the technological learning environment created closely mimics real-life learning and/or real-life working environments. Unless the technology employed is enhancing the learning of the students it will never fully engage them thus failing in creating an active learning environment which is the foundation of current student-centered learning and faculty-facilitator models.

5. Linear vs. non-linear design

What has traditionally been missing or been slow in terms of implementation in courses designed for online delivery is the use of a controller. Currently, most (if not all) courses created for online delivery can be considered to be static from a design/material point of view and furthermore they are usually also linear.

The design of the course as well as the learning material included in a course are not or cannot be adjusted based on indications of the performance of students and are simply fixed in space and time. The only parameters of this learning system that makes the entire system active is the existence of the human factor: the faculty and students. In the mathematical or engineering sense, the addition of faculty and students makes the system a dynamical system and furthermore it can be argued that a dynamical eLearning system is inherently non-linear and can exhibit a completely unpredictable behaviour, which might seem to be random, despite the fact that it is (fundamentally) deterministic.

This is important because most courses developed for online delivery are usually developed to address a widely diverse audience comprised of learners at various levels of competency and ability. A course developed to be linear in nature may fail to address all of the learners' needs at their level. The ideal choice then is to create a non-linear course (assuming that this is possible for that particular course). Learners at the lower levels of ability can still have the option to progress through the course in a linear fashion, while those who are able to, can move through the course on a more customized and personalized path.

In a typical linear eLearning course, faculty, course developers or instructional designers have fixed learning materials usually broken up into pages, units or modules with locked navigation: only when a learner completes a certain module, can he/she then access the subsequent module for example. This two-dimensional linear approach can be applied to each content page, unit, or module in that course (Figure 2). All learners are forced into this single-mode, sequential pedagogy based on what the faculty or instructional designers have predetermined this necessary order to be. There's no doubt that the chosen order should follow a logical flow of information, from the simplest to the more complex, which is simply following the order found in a printed textbook. However, unlike a printed textbook where the reader can flip through or open at any page required, in an online course flipping through locked content pages, units or modules is not possible according to Robberecht\(^15\). In fact, even moving at their own speed through the learning material may be impossible for more advanced learners since locking pages, units or modules usually is followed by locking the timeframe during which these materials can be accessed as well, thus preventing learner motion through time as well as space. Using the facilitator model of instruction in a linear course also limits the role of the faculty as learning manager.
Ideally, each learner in an online course should be able to enter at his/her own chosen starting point and progress through existing learning material on his/her own pace in a manner that is personalized based on his/her own level of ability and learning style. Some recent Massive Open Online Courses (MOOCs) have attempted to do that even though the majority still seems to follow a linear model (and many actually lack the existence of any learning managers whatsoever).

In a non-linear, non-sequential course design, the responsibility of the mastery of learning material and course objectives shifts almost entirely to the learner (Figure 3). The faculty, in accordance with the facilitator modell as posited by Roubides and student-centered philosophy as described in O’Neil, Moore, and McMullin, still is actively involved in providing guidance and controlling the learning process.

The design of such a system, however, is much more complex, requires more knowledge, time and resources, and also requires a learning management system that allows the development of such designs as Robberecht suggested. For most college or university faculty, instructional designers or course developers, the requirements to create such designs far exceed available resources, therefore creating a design that would certainly accommodate and engage all learners in an online course resulting in a positive and cognitively enjoyable experience is simply far too optimistic and usually out of reach.

This leaves most faculty with the restriction to develop courses based on a linear, either two- or three-dimensional design but still passing on to the learners the responsibility to master course objectives themselves. In this scenario the role of faculty can be diminished whether by design or on purpose from enabler and manager of learning to a little more than an observer in many instances. In Roubides, a case is described when during a recent peer review of an online course the following statement was found in a prominent location within the observed faculty's course syllabus: “This is a self-taught course; if you can't teach yourself, please drop this course and take an on-ground course instead.” This course was not a MOOC-type course but a regular college-level, credit course offered online semester after semester by a full-time salaried faculty. The question thus comes naturally, what is it that's missing from such a system?

6. A perturbed system

In the previous example of what faculty's own perceptions may be about online course delivery, what is really missing is the controller. In the absence of a controller the closed loop control system shown in Figure 1 is now employing a sensor whose feedback is directed to the plant itself. Recall that in the control theory metaphor, the plant is the learner, and the learner may or may not have the ability, knowledge or experience to even interpret the feedback and self-regulate as Artino discussed, constituting the sensor itself either nearly useless or simply becoming just an assessor of the system output (Figure 4).
Csikszentmihalyi’s investigations of optimal experience have revealed that what makes an experience satisfying is a state of consciousness called flow. He has demonstrated ways in which this positive state can be controlled and not just left to chance. In an analogue taken by the recent trend of gamification, which posits that techniques currently used in gaming are also transferrable to eLearning, Raymer depicts the optimal flow channel of learners as shown in Figure 5a. As the challenge of the learning experience increases, so must the skill of the learners also grow in direct proportion. If learners' skill exceeds the challenge of the experience, they will become bored or disengaged; on the other hand, if the challenge of the learning experience exceeds the learners' skill, they will suffer anxiety and also disengage.

Unless there is a belief that somehow a learning system can be successful even in the absence of a controller, regardless of the form that this controller may take, it would then mean that it is a necessary component of the system and hence must be addressed by the faculty, instructional designers, or course developers or else the optimal flow channel described by Csikszentmihalyi and Raymer cannot be achieved. The addition of the controller will regulate the system by frequent adjustments of topics and topic assessments, as well as goals and objectives in order to keep the learners within the narrow but optimal flow channel (Figure 5b). In other words, perturbations in the entire system may be necessary to achieve the desired outcomes.

In the traditional view of faculty as course developers and course delivery experts, the time investment and knowledge required to perturb their eLearning systems (online courses) in order to accomplish the optimal flow channel for all students, especially if this has to be done for each student individually and at each student's personal level, is simply either not available or there is no willingness to make such an investment. And if this is the case, then one of the most important issues regarding the design of courses developed for online delivery as well as the role of faculty in delivering such courses still remains unaddressed.
7. Discussion

In situations as described using the control theory metaphor above, the repercussions can be rather serious. Learners can feel isolated and/or confused, suffer from increased levels of anxiety, and otherwise risk disengagement with the course; this may in turn lead to poor retention and success rates. In general, as described in Roubides\textsuperscript{16}, there are several factors that affect retention and success in online courses. These can be broadly categorized into course design-related factors, course delivery-related factors, and student-related factors. Of those three, only the first can be immediately directly addressed. Furthermore, course design can also affect how a course is delivered by faculty and how it is used by the learners. Hence, a flawed course design could play a fundamental role in rates of retention and success of online learners.

This has been observed to be especially true in those courses that employ software platforms for assessment and testing. This is not to suggest that such systems are not appropriate or useful; on the contrary, they could add significant value to an online course. Having said that, as with every type of technology use, it is how the technology is being used that can make the difference. It is very enticing (and very easy) to depend on the particular technology selected for an online course and miss the fact that any course, in the absence of appropriate controllers, can easily result into unwelcomed poor retention and success of its users.

As an example of this gap in course design and potential effects on student retention and success, a single online course in College Algebra designed with the aforementioned issues in mind was selected to showcase the observed difference in success rates against the average success rates of all similar courses for three consecutive semesters during one academic year at Broward College (\textit{success} is defined here as having achieved grades of A, B, or C). It is easily seen by visual inspection that there seems to be a large difference in observed rates of success which are of the order of 25-35\%. Even though no statistical analysis has been conducted to prove that this observation is also statistically valid, it is the author's observation from experience that it probably holds true.

![Percent success rates in online College Algebra courses](image)

Fig. 6. Success rates in an online College Algebra course.

8. Recommendations

In order to justify any claims that courses without active controllers or regulators would result in lower rates of retention and success, statistical studies analysing quantitative or possibly qualitative data ought to be conducted. For the example shown of the College Algebra course, a larger-scale quantitative study about factors that may affect online student retention and success in that course is already being developed. It is further recommended that separate
qualitative studies examining both faculty and students’ lived experiences, views, and perceptions on why students in such courses may become disengaged and what factors would contribute to continued engagement. Many studies in the area of retention and success seem to take a purely quantitative approach even though it does seem logical that perhaps qualitative studies may also equally contribute to understanding the issue.

Aside from conducting research studies to examine the overarching resulting issues from flawed online course designs, immediate fixes include promoting self-regulation of learners as the missing controller component. Schunk described self-regulation as “processes that learners use to systematically focus their thoughts, feelings, and actions on the attainment of their goals” (p. 441). This definition coupled with the prevalent constructivist worldview of teaching and learning is often mistaken to mean that students online must be able to be self-taught. This however is a fallacy and therefore teaching strategies to promote self-regulation skills are still required. Several such strategies have been described by many researchers over the years and are available in current literature, such as in Roubides and Wojcik, who suggested that “the self-regulatory processes that have the greatest impact on academic success include self-monitoring, self-evaluation, time management, modeling and collaboration, self-efficacy, and task value. Instructional scaffolding of self-regulatory strategies employed within the online classroom can positively influence students’ self-regulation abilities” (p.13).

9. Conclusion

This monogram presented an empirical review of how many online course designs may be lacking the appropriate components for creating, what is called in engineering control theory, a closed-loop system. An interpretation of certain online course designs was offered through the lens of engineering theories, more specifically, engineering control theory. An online course, just like a mechanical system, requires an input, a plant, and a sought-after output. The components of an online course form a dynamical eLearning system in which, similarly to its mechanical counterpart, the mere presence of its components, with or without any sensor, and despite the quality of those components, cannot result in an optimally controlled system without the presence of a necessary controller.

Many courses slated for online delivery appear to follow this controller-lacking flawed design. The implication of such a commonplace flawed design, and/or faculty perceptions of their own role in online learning, is that online learners may simply be left to their own devices regarding how to manage or interpret stimuli or feedback provided to them by the learning system, and what course of action or change in course of action may be necessary. Therefore, success in online courses becomes a function of the learners' ability to self-regulate – a notion that is often confused with the ability to be self-taught, as argued by Schunk – and in turn, a function of the learners' ability to reach their learning goals, frequently, on their own.

In order to address this design issue, which may be a contributing factor to poor retention and success rates among online learners, it is recommended that educational institutions or other providers of online learning first look to course design factors as possible culprits. The design of online courses in turn can affect the role of the faculty delivering these courses and overall outcomes of the courses themselves. The topic of retention and success at different levels of the educational spectrum and at various settings has been researched for many decades with yet no single solution found. The rapid expansion of online learning in the last decade brought with it a renewed concern about low rates of retention, low satisfaction, and less than ideal learning outcomes. It is a duty therefore of all stakeholders to add every possible scenario in the long list of possible factors permeating this issue, starting with the one factor that is the most directly managed and controlled: online course design.

References


