

# Issues with Online STEM Education – Assessment and Accreditation

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**Abstract** – Online programs are constantly growing in number. There is a variety of issues facing online education, e.g., possible lack of eye contact, its impersonal nature, etc., that affect the quality of and attitudes toward the programs. We propose that comparison of online education to traditional education is best approached from the viewpoint of quality. Further, quality of online programs and courses should be characterized in terms similar to traditionally delivered ones, i.e., in terms of outcomes and outcome assessment, rather than by focusing on the medium per se. Adoption of the quality standard of outcomes assessment has the advantage of allowing opportunities for continuous improvement to be identified. By focusing on what objectives and outcomes are achieved, rather than the details of how, outcomes assessment also fits well with the goal of accreditation agencies to develop more practical guidelines to be applied to online programs.

*Keywords:* outcomes assessment, online infrastructure, emerging technologies, accreditation, learning.

## THE INCREASING PRESENCE OF ONLINE EDUCATION

Online education is fast becoming an integral part of many colleges and universities [1]. The reasons for this apparent trend are many and various, some of them related to the very mission of the universities. The once pervasive attitude that equated online universities with diploma mills has changed significantly, although some negative perceptions continue. Some universities that have focused mostly on online audiences have increased their enrollments from robust to formidable, and many universities and colleges, having acknowledged that fact, have started studying the feasibility of online instruction.

There has been an increasing demand for higher education, as evidenced by increasing enrollments at universities. For example, one of the strategic goals of the public University System of Georgia is to increase its capacity by 40%, from about a quarter million to about 350,000, by 2020. Georgia also recognizes the need to reach prospective students regardless of their geographic location, partly by increasing the *percentage* of credit hours generated through distance education for several years [2]. People living in areas located too far from institutions of higher education or from those offering specific programs of interest and without the ability or willingness to relocate, do not have many options other than online education. Specifically for the science, technology, engineering, and mathematics (STEM) disciplines, a variety of indicators, published by the Business and Higher Education Forum and the National Science Board over the years, point to the need for increasing the number of graduates in these areas (especially in comparison with some developing countries), as well as to the trends in that direction [3][4]. Moreover, there are specific constituencies, such as employees of the military, who relocate often and are therefore critically dependent on online education, and an increasing base of working students depend on online offerings for addressing scheduling conflicts and commuting issues.

There are perhaps other factors, too, that are instrumental in the increasing number of online courses and programs at colleges and universities. While effective online offerings require important resources, one resource that they are *not* as dependent upon as face-to-face offerings is physical space. There were times

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when the authors, in their roles as educational administrators, were able to add a new online section of a course late in the registration cycle relatively easily, while other sections with specific physical space requirements were much harder to add. Instructional technologies have also come a long way from the days of blackboards and overhead transparency projectors, enabling a whole new range of instructional and pedagogical options. Over the past decade or two, instructional technologies first turned classrooms into multimedia laboratories, and with the pervasiveness of the Internet, have opened up a host of synchronous and asynchronous online education options. Pedagogical discourses have more or less kept pace with technological advances, ranging from research into the effective use of presentation packages (such as PowerPoint) to the integration of collaborative 3-D virtual learning environments (such as Second Life) into the teaching/learning process.

## **MAJOR ISSUES IN ONLINE EDUCATION**

The increasing demand for online courses and degree and certificate programs might imply a mature educational paradigm, but the reality is far from so. There are major issues and challenges that confront online education. These issues and challenges may be categorized as (a) those relating to the attitudes and perceptions of students, faculty, and the community; (b) those involving to the somewhat impersonal and nontraditional delivery mode; (c) those relating to what students learn and how their knowledge is certified, assessment of program and faculty effectiveness, etc.; and (d) funding and support for online infrastructure and delivery. These categories are examined below, with the intent of identifying an approach toward quality and effectiveness in online instructional settings.

### **(a) Attitudes and Perceptions**

Different groups, such as students, faculty members, administrators, employers, and the larger community, carry different perceptions and attitudes toward online education, which affect their participation in, success with, and/or acceptance of online education. While some of these attitudes may be shared between different groups, each of the aforementioned groups has different stakes in online education, which impact their feelings and outlook. To some degree, all groups share some reservations (and perhaps some unfounded biases) about the effectiveness of this new mode of knowledge delivery and learning.

In addition, students seem to view online courses with a preconception that they are either very easy or impossibly hard. What easy or hard means to individuals can also vary; it might be defined in terms of how easy the course (and perhaps, getting a good grade) would be, of how enduring their learning would be, or just of convenience. It is easy for some students to confuse the absence of physical class meetings with absence of student responsibility. Some students might misguidedly slack off owing to the syndrome of “out of sight, out of mind”, only to realize too late that they have fallen hopelessly behind. Other students stay away from online courses, equating the lack of physical class meetings with a lack of meaningful instruction. To be sure, both extremes (too easy or too hard) are based in reality; programs that do not recognize the underlying issues and address them could indeed offer easy grades without adequate high quality instruction and/or without challenging students sufficiently, or they could fail to provide adequate support or even make it impossible for students to succeed in an online environment.

Some faculty members prefer to err on the side of caution and consequently, either refuse to believe that effective online instruction is possible when various resources are brought together in the right balance, or feel it is too hard to do an effective job of teaching online. At an extreme, some also tend to equate online degrees with a lack of quality. Once again, this latter position perhaps has some basis in reality, but ignores (or underestimates) the vast potential of evolving pedagogical approaches, instructional technologies, and the sheer motivation that sometimes comes from the convenience and flexibility that online education affords students. One might argue that a teacher’s ability to realize such potential in an online setting is not unlike the ability of a knowledgeable person to get his/her knowledge across and facilitate student learning and discovery through appropriate activities in a traditional setting. Good teaching always takes much preparation and work, as well as perhaps an inspirational spark.

An important goal of educational administrators is to optimize enrollments, instructional quality, resources, etc., while staying true to the institutional mission. Online courses and programs are clearly attractive in relation to enrollments and resources, but with the caveat that enrollments tend to follow perceptions of instructional quality, which in turn requires investment of resources. An important issue in this context is

the possibly oversimplified perception that teaching is the same independent of the medium/mode of delivery. In stating that good teaching always takes much preparation and work, as well as perhaps an inspirational spark, there is the danger of ignoring the differences between the media and the modes of delivery.

The stakes that employers and the larger community hold in the context of online education relate to the quality of graduates. The ability of graduates from online programs to contribute as future employees (and more broadly, as citizens and future taxpayers) at levels comparable to graduates of traditionally delivered programs is the ultimate proof of the pudding. This is a view consistent with the emphasis accreditation agencies tend to place on the interests of various stakeholders, which we return to in the next section.

### **(b) Delivery Mode**

There are important issues and differences in online education that are attributable to the different delivery mode and medium. Some of the perceptions and attitudes outlined above relate closely to such differences. A physical classroom setting involves several attributes of instruction that are taken for granted, including the guiding physical presence of an instructor, the instructor's ability to gauge student interest and engagement in the class proceedings, the sense of community of a group of cohorts, the all-important eye contact, the inflections and tone of the instructor's voice during a lecture, the ability of the instructor to organize students into small groups for discussion or other activities, help sessions during faculty office hours, the ability to engage in hands-on lab activities, live illustrations and demonstrations, vigorous two-way/multi-way debates, question-answer sessions and discussions, team projects, proctored testing, etc.

Most of these activities and attributes of traditional classroom instruction have been so much a part of our educational culture that most educators and students have come to view them as integral and inherent to instruction. Good teachers know, however, that not all attributes are important to every student, and different students have different needs and different approaches to and styles of learning. In separating the teacher and the student, distance learning creates challenges in relation to most of these attributes. Fortunately, the online medium, however, allows one to address many of them. Lectures and modules with audio and video streaming, live web-based classrooms, chat rooms (including audio and video) that can be configured in interesting ways, email and discussion groups, etc. are supported by instructional technologies. Such technologies can be supplemented by ubiquitously available proctored testing services, archived live and discussion sessions, virtual collaborative environments, simulated experiments, virtual lab sessions (which can be supplemented with a small number of actual lab sessions when critical), course management packages that track student progress and invite instructor intervention, etc. Just as with traditional classroom instruction, the sooner the instructor completes a "getting-to-know" protocol with each student, and also creates a perception for each student that the instructor is aware of the student, the more likely it is that the student will remain with the class and interact with the instructor as needed and expected.

It must be acknowledged that as advanced and well-developed as current instructional technologies are, they still suffer from design, technological, and user interface limitations, and are far from mature. Students that can only thrive in a traditional classroom setting will likely find the most advanced instructional technologies to be too limiting. The choice for such students would be between remaining in a traditional setting and investing extraordinary amounts of time and effort in getting comfortable with the potential of new technologies. Yet there will be others that will derive extraordinary motivation from the convenience and flexibility offered by such technologies, especially as many are relatively simple to use for somebody who is savvy with or quickly learns technologies. Certain activities might benefit from exploiting the strengths of the online medium, e.g., teamwork among geographically distant group members, which is particularly relevant in today's globalized work environment. Most students are somewhere in between as are most instructors, who will go through a learning curve as they get comfortable with the potential of the new medium. Facilitating this transition for the late adopters is a challenge that requires initial resources and investment.

### **(c) Funding and Support**

Another major issue in online education is the initial and ongoing investment required to support online course development, delivery, and related support services. Above, it is pointed out that facilitating the transition to the online medium for faculty and students requires an often significant initial investment.

Resources are required for developing courses for the new medium so its strengths are exploited and weaknesses are compensated for. Resources are also required for training faculty members to develop and deliver courses effectively in the new medium. In addition students need to be oriented to the new mode of delivery, to details of how expectations differ and yet remain the same, what kind of support and help can be expected, etc. In some cases, substantial initial investment might also be needed to put in place the technological infrastructure necessary to support online instruction.

Further, there are some additional, not so obvious aspects that need to be funded in relation to online programs. First, given the fact that students might never set foot on campus, essential services that normally assume students would physically be on campus in order to take advantage of those services need to be redesigned and supported to serve online students. Do some or all library services need to be made available online? How can advising be supported? Is it the case that various petitions, e.g., those for graduation, are available and can be completed online? As already mentioned, if some lab experiences are critical, means should be provided to address them in creative ways. Appropriate mechanisms also need to be supported to recruit students and offer career services to students and graduates consistent with the educational mission of the institution.

#### **(d) Student Learning, Outcomes Assessment, and Faculty Effectiveness**

As with any educational mission, online education has two broad goals that have competed with each other from time immemorial, namely facilitating student learning and certifying student learning. Many of the issues discussed so far deal with effectively facilitating student learning. The online instructor is perhaps more of a facilitator for effective learning than a teacher per se, almost certainly more so than an instructor in a traditional classroom. Certifying student learning generally involves assigning a grade to each student in each course. We have already dealt with an important issue in this context, namely, proctored tests, which involve a disinterested party supervising the testing process for each student. Other related questions of ensuring academic honesty, e.g., take home projects, term papers, etc., are important, too, but are perhaps no different in an online context than the traditional setting.

On the flip side, there are important questions of assessing the entire educational process itself. There are a couple of aspects to such assessment, too, namely program outcomes assessment, and assessment of faculty effectiveness. First, assessment of faculty effectiveness is a hotly debated topic, but the issues are no different in an online setting compared to the traditional context. It could perhaps be argued that with hardly any face-to-face meeting between students and the faculty member, student evaluations of the faculty member are likely to be much more objective than in the traditional setting, for they would solely be based on online interactions, and possibly a variety of other modes (including audio and video) that are chosen by the instructor.

Next, let us return to the topic of program outcomes assessment. In a way, program outcomes assessment amounts to assessing the whole process, how well student learning is facilitated, what they have learned, the effectiveness of the faculty member, etc. More importantly, outcomes assessment summarizes how well the program's learning outcomes are achieved by the students. Previously, it has been mentioned that the quality of online programs may be judged (the proof of the pudding) by the ability of graduates to land and contribute to jobs in their fields at levels comparable to graduates of traditionally delivered programs. With appropriately defined program outcomes and objectives, assessment could address all these desiderata.

In fact, in the next section we propose assessment of program educational objectives and outcomes as a test stone for quality of online programs. This unified approach to quality also involves making appropriate adjustments to accreditation criteria used by various organizations. While most of our recent accreditation and assessment experience has been in relation to SACS and ABET, Inc., as well as AACSB International, albeit on a more limited basis, our experience with international accreditation agencies suggests that this approach has broad applicability.

### **A UNIFIED APPROACH TO HIGH QUALITY ONLINE EDUCATION**

We propose that the many challenges described in the previous section are best approached from the viewpoint of quality in a broad sense. Moreover, given that the overall aim of online programs is not that dissimilar from traditionally delivered programs, namely to prepare graduates to achieve certain objectives

(e.g. settle in professional careers, including research careers), the quality of online programs and courses is best characterized in terms similar to traditionally delivered programs and courses, rather than by focusing on the medium per se.

The most widely accepted quality standard in higher education is based on the concept of quality as fitness for purpose. In other words, programs are expected to formulate a set of expected performance criteria for their graduates to achieve, to develop and deliver a program of study that allows graduates to achieve the performance criteria, and to set up an assessment process relative to them. The assessment process determines to what extent graduates do actually achieve the expected performance criteria and feeds into a continuous improvement process that uses data obtained in this way to further improve the program. Clearly, the infrastructure used to deliver the program and other support must be adequate to help the program's graduates achieve the performance criteria. Outcomes assessment allows one to focus on what is achieved, rather than the details of how it is achieved.

While admittedly still vague, this view enables faculty and educational administrators on the one hand to identify opportunities for improving online programs and courses in meaningful ways, and accreditation agencies on the other hand to develop more practical guidelines to be applied to online programs. Outcomes assessment should also be supplemented with attention given to the online infrastructure to support appropriate level of student learning, advising, and progress toward degree completion, similar to the way in which an assessment of a face-to-face program will focus on the physical infrastructure that is in place. A careful consideration of issues related to student success and retention complement the focus on successful graduates.

The criteria used by ABET, Inc. for accrediting programs in computing, engineering, and technology disciplines are in the process of being harmonized as much as possible. However, they all share a common framework. Several of the criteria relate to assessment and continuous improvement, and the rest of them relate to student support, curriculum design, faculty qualifications and work load, facilities (including laboratories), and financial support. The criteria used by regional accreditation agencies, such as SACS, focus on a variety of factors and include emphasis on outcomes assessment and technology infrastructure.

Drawing from the terminology defined by ABET, Inc., the assessment and continuous improvement process starts with identifying broad program educational objectives describing what graduates are expected to attain within a few years after graduation, along with outcomes describing what students are expected to know and be able to do by the time of graduation and related to the skills, knowledge, and behaviors that students acquire in their matriculation through the program [5]. These objectives and outcomes are identified based on the needs of the major constituencies of the program. A program is assessed by first collecting data relative to its objectives from alumni, employers, possibly industry advisory boards, etc., and by collecting data relative to its outcomes based on actual student performance, as well as a variety of other means. The data thus collected are organized, analyzed, and interpreted relative to the objectives and outcomes they are supposed to evaluate. Techniques of practical assessment are well-studied topic, and a variety of measurements, methods, and techniques are used in assessment [6]. Assessment allows a determination of which of the objectives and outcomes have been met during each cycle. If some of them are not met, the data and analysis reveal opportunities for improvement. Some of these opportunities might, for instance, point to specific improvements needed in the technological infrastructure. On the other hand, some of the issues discussed before might turn out to be non-issues. For instance, the lack of eye contact and the lack of cohorts to talk to could be non-issues in an online program intended for mature working students that are highly motivated by its flexible schedules, perhaps because some courses require archived online group discussions among small teams every two weeks.

While not critical, it is customary for the team of evaluators to meet with alumni and advisory board members during a site visit. Advisory boards for online programs would be able to serve the program better if they include some employers and alumni from remote areas that are largely served by the program. After all, the program educational objectives, which relate to the goals achieved by graduates of the program a few years after graduation, are to be based on the needs of various constituencies, such as employers and alumni.

Other criteria would have to be interpreted appropriately in the online context. For instance a criterion that focuses on student support would study support for online advising and career mentoring, support for other student services (such as tutoring, career services), mechanisms to ensure timely progress toward

graduation, etc. Accreditation teams typically interview current students, and in an online environment, this can still be facilitated through a live online meeting session, authenticated by the course management package typically used by the program.

Generally speaking, the curriculum supporting a degree program would be independent of the delivery mode, although there could be some online-specific elements, such as a short online orientation course in the online version of the program. However, the medium may pose some additional challenges for programs that include program outcomes related to public speaking, or program outcomes that one would normally expect to be achievable only through extensive hands-on laboratory experiences.

In general, faculty qualifications would not be expected to be different, except for two issues. First, as online instruction requires skills that are different from those required for face-to-face instruction, some questions may arise about how an online program ensures that its teaching faculty has the required pedagogical skills. Second, faculty workload and instructional support would need to be appropriate for delivering the program effectively. For instance, it is important to make sure there is adequate opportunity for all online students to interact with the instructor (and if applicable, any teaching assistants) for effective instruction. The team of evaluators should explore such issues during their interviews of students and faculty members. It is also reasonable to expect that the program have an adequate number of full-time faculty members to support the program, just as would be expected with traditionally delivered programs.

Institutional facilities that support the program would be a major focus in the context of online programs. Library facilities should be adequate to support the needs of students and any potential shortfall in this area should be addressed appropriately, e.g., the library should make the necessary materials available to individual students as needed, within the framework of copyright laws. The information technology infrastructure and the instructional technology infrastructure should be reliable and adequate to support the needs of the program; the degree of adequacy may be judged through student and faculty interviews, as well as through other means, e.g., a demonstration. Support for specific types of laboratory experiences would be of particular interest and should be consistent with the intended outcomes and objectives of the program. Combinations of strategies and tools judged as adequate and appropriate for specific contexts may be used, such as remote access to certain *licensed* software tools, simulations, pre-lab exercises, possibly in virtual collaborative environments, sometimes supplemented by the requirement of intensive on-site laboratory experiences (requiring a physical site visit by students). This is a fertile area of research, with a number of virtual laboratories available for exploration on the world-wide web and others in development [7]. More developments may be expected in this area in the near future.

In the context of traditionally delivered programs, the financial support criterion focuses on institutional commitment to hire and retain the faculty members needed to support the program and to support laboratories and other infrastructure needs. The emphasis of this criterion would also be adjusted in much the same way as with the institutional facilities criterion above. Considering that instructional technologies continue to evolve in the near to medium term and considering that significant developments related to remote laboratory access may be expected over the years, it is important for institutions to show a commitment to support online programs as needed.

## CONCLUSION

We have pointed out that a variety of factors have led to an increasing need and demand for online programs. As the demand increases for online educational programs, a variety of issues associated with various aspects of those programs assume great importance. We have categorized those issues into those related to attitudes and perceptions of various constituencies, those related to the new medium of instructional delivery, those related to funding support for such programs, and those dealing with assessment of various aspects. Finally, we argued that while the various issues are important and appear daunting, it is possible to approach them in a unified manner by viewing them as affecting the overall quality of online programs, which in turn may be addressed through assessment, leading to continuous improvement. We have also identified how several commonly used accreditation criteria might be modified to the context of online programs. However, we are convinced that the outcomes-based approach to accreditation, which has proven so successful in face-to-face programs, is also highly applicable to online programs and provides the best method for ensuring the quality of such programs.

## REFERENCES

- [1] Allen, I. and Seaman, J. *Making the Grade: Online Education in the United States, 2006 - Has the Growth of Online Enrollments Begun to Plateau?* Babson Survey Research Group. 2006, Retrieved March 4, 2007 from <http://www.sloan-c.org/publications/survey/index.asp>
- [2] Board of Regents of the University System of Georgia, *University System of Georgia Strategic Plan*, <http://www.usg.edu/strategicplan/>, 2008.
- [3] Business and Higher Education Forum Report, *A Commitment to America's Future: Responding to the Crisis in Mathematics & Science Education*, <http://www.bhef.com/publications/MathEduReport-press.pdf>, January 2005.
- [4] National Science Board Report, *Science and Engineering Indicators 2008*, <http://www.nsf.gov/statistics/seind08/pdfstart.htm>, 2008.
- [5] ABET, Inc., *Criteria for Accrediting Computing Programs – Effective for Evaluations during the 2009-2010 Accreditation Cycle*, November, 2008.
- [6] Dasigi, V., “Practical Program Outcomes Assessment: A Case Study,” *International Conference on Engineering Education (ICEE-2006)*, San Juan, July 2006, pp. T4A1-T4A5.
- [7] Gustavsson, I., “User-Defined Electrical Experiments in a Remote Laboratory,” *Proceedings of the 2003 American Society of Engineering Education Annual Conference and Exposition*, Session 2359.

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