Traditional vs Non-traditional Teaching and Learning Strategies – the case of E-learning!

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Abstract: The traditional teaching approaches are generally teacher-directed where students are taught in a manner conducive to sitting and listening. It is true that traditional philosophies often allow us to continue with the lecture-based model with some useful results. However it is often argued that the traditional approach may not provide students with valuable skills. The teaching of mathematics that is usually referred to or called non-traditional uses constructivist philosophy as its basis; this implicates strategies in which an individual is making sense of his or her universe. So the student is an active participant, which may help develop, construct or rediscover knowledge – a major goal that can be a time consuming process if taken literally for each student; alternately, there is also a philosophical position known as social constructivism suggests group work, using a specialist language of the field, and discourse learning its cultural framework; social intercourse and problem solving being the most important part of learning process. It is argued that the non-traditional teaching is done using a problem solving or inquiry based approach; where the learner is the problem solver. Therefore, e-learning is considered to be more in line with the non-traditional approaches than the traditional. This paper critically reviews the literature on mathematics and engineering learning in terms of these approaches and compares them. The paper specifically examines the advantages/disadvantages of the approaches as well the manner in which they influence performance of students in mathematics and engineering courses.

Keywords: Traditional, Non-traditional, E-learning, Higher Education, Science Technology Engineering and Mathematics (STEM)

1. Introduction

This paper is as much a reflection upon more than 20 years of in class teaching of students in both high school and tertiary in several countries, as an in depth and critical examination of recent research on mathematics teaching with a focus on higher education in STEM subjects; in light of the advancements in technology thus far (Science, Technology, Engineering and Mathematics) (Tularam & Keeler, 2006; Tularam and Ilahee, 2007, 2008; Tularam, 2011, 2013ab, 2010, 2015). In the past thirty years in particular, there has be a concerted effort to develop students’ conceptual understandings of mathematics often at the expense of practice, memory, and negatively labelled instrumental learning. The case of demonizing any teaching related to rote learning, instrumental or procedural understanding has been espoused (see, Abdulwahed et al, 2012; Kelson & Tularam, 1998ab; Tularam, 1997, 1998, 2015). The past thirty years have seen many changes in the system of delivery in education worldwide. In most cases, the methodologies tend to be derived from mainly the following constructivist authors: Piaget’s cognition, Vygotsky’s socio-cultural and von-Glaserfield (Piaget among others) constructivism. It is said that the traditional teaching method is not consistent with the above and therefore a number of new methods have been devised over time (Abdulwahed et al, 2012). The new technology has also enabled such philosophies to persist in
classrooms of today but there are a number of disadvantages as well as advantages and these are to be highlighted in this paper. The main aim of this paper is to compare the traditional and e-learning approaches and further to examine whether the shift towards teaching mathematics has moved too far from the centre in the use of technology as means of achieving the best for mathematics and engineering students. Have we learned from past mistakes of history given the current situation of such low levels in both mathematics and science in Australia? Have we appropriately critiqued the theoretical positions espoused (even that of constructivism) in relation to the mathematics taught in engineering and sciences more generally.

2. E-learning and background to traditional teaching

There are a number of definitions of e-learning (also called elearning or eLearning) but Stockley’s (2003) definition appears appropriate for mathematics education. “Elearning involves the delivery of a learning, training or education program by electronic means. E-learning involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material.” (http://www.derekstockley.com.au/elearning-definition.html) Clearly, the actual procedures used in E-learning environments can be varied such as online training or education, Internet or an Intranet, CD’s and DVD’s and so on. It seems that distance education was one of the first areas that used e-learning in its delivery. Interestingly, the learning of e-learning is considered “on demand” thus overcomes many of the issues that plague the modern tertiary student attending lectures on time, avoiding parking at universities and other difficulties faced in travelling to places of learning for example. A combination of various methods, including traditional based online 24/7 lectures and tutorials can also be included e-learning but this type of combined effort is usually referred to as blended learning.

In brief, a computer that allows students to interact online and in real time may be referred to as an e-learning environment. A two or three dimension figure can be very useful in demonstrating geometrical work and graphing in mathematics and engineering. The algebra manipulations may also be presented in a more colourful and perhaps meaning ways using computer software such as Matlab and Mathematica etc. While not being concrete objects (of real life), it is in fact possible to represent pictorial and 3d graphs that do help bring mathematics to real life all be it in two dimensions mostly (Hollebrands & Lee, 2012). There are many examples of such e-learning environments in mathematical (e.g., The Geometer’s Sketchpad, GeoGebra, Cabri); and statistical environments (e.g., Fathom, TinkerPlots). In such programs students may be able to manipulate objects etc. although not physical real life objects (Hollebrands & Lee, 2012). The software programs are designed to help students understand relationships, develop deductive and logical arguments using many examples for practice. It is argued that the programs may help reinforce mathematical interconnections with exercises that provide almost instantaneous feedback. The pictures and objects tend to concretize mathematical concepts so that the learner can explore mathematical relations between variables (Baccaglini-Frank & Mariotti, 2010; Hennessy & Deane, 2008). Some research shows that students do from deeper and a more interconnected mathematical understanding in e-learning environments (Dick & Hollebrands 2011; Duval, 2006).

To examine the success of such environments there are mainly early school studies and some high school studies, but very few tertiary based studies. In most cases in such studies the students are asked to complete problem solving tasks and they are observed for their behaviour both physically and cognitively through interviews and success - measured by their ability to perform successfully the required task. The author has done much work in this area and examined problem solving in algebraic and mathematical problem solving studies over a period of more than 20 years (Tularam, 1997, 1998, 2013, 2014, 2015). In fact, there is a related study that is presently in press, which has

*International Conference on Engineering Education and Research 2016, Sydney, Australia*
investigated trajectories of students during their solution process when asked to complete tasks. Each student trajectories of problem solving were examined and the author noted that student access to technology in general may not assist their mathematical problem solving and may at times hinder it even further (unpublished paper). Student often copy and paste the solutions to assignment problems similar to those found from the internet without any level of understanding. This was noted when students were asked to explain their solutions.

The e-learning environment is a new concept of teaching and learning with the aim to increase the effectiveness of teaching. However, Colace et al (2014, p. 9) argued that the aim is to increase the quality and effectiveness but that of the “traditional teaching” itself rather than aiming for another totally different method. Clearly, this has different implications and may indeed be in line with the present thinking as will be noted later. The purpose of this paper also falls into the general aim of Colace et al’s work. They wanted to know whether an e-learning classroom environment is an effective learning environment for children when compared with a traditional learning environment. The change has been occurring mainly due to the advancements in technology that has in fact improved the nature of e-learning processes immensely but for which audience – for the self-directed or highly motivated or more generally. The environment that creates and engages students and also has a sound and meaningful academic basis will in the end aid planning and decision making: thus will drive the future of mathematics and science teaching.

3. Comparison of traditional teaching and e-learning

An older study by Harrington (1999) found that traditional face-to-face course did well overall, but the student GPA was the major predictor of success. The findings showed three main differences in that the online students were mainly female, older with more experience than the face-to-face instruction group. The online completions had a greater college credit hours than face-to-face completions (F=3.76, df=3/97, p<.01). The face-to-face withdrawers had earned substantially fewer credit hours than online withdrawers. In both delivery types, the course completers who failed had significantly lower cumulative GPAs than either successful completers or withdrawers.

Academic advising or personal contact with the instructor was important, particularly for who marginal students. Benard et al (2004) stated that background variables significantly contributed to the academic performance for both online and face-to-face students. Inactive decision making meant that students set themselves up for failure by simply not being prepared enough for the courses chosen but those who did the work were not prejudiced by methodology. Also there was no difference in withdrawal or failure rates. Zang (2005) examined the effectiveness of computer-assisted instruction (CAI) versus traditional lecture-type instruction on triangles (younger students). The students in the control groups were taught the concepts of triangles in their traditional classes, while the students in experimental groups were instructed in a computer lab. No statistically significant difference was found between the students’ achievement. Shallcross and Harrison (2007) examined Chemistry lectures from years 1-4 for differences between three delivery methods - Category 1: used only electronic media to deliver courses, Category 2: used a mixture of electronic and non-electronic; and Category 3: which used non-electronic only. The students and lecturers both preferred non-electronic methods but no significant differences were noted amongst the methods. However, students felt that the material covered a lot of work and student needed hard copies of the notes for learning. Some felt the diagrams used were rather complicated and at times seemingly irrelevant images were being used. Also, the online lectures were presented quickly.
Spradlin (2009) using analysis of covariance showed no significant difference in scores of students receiving traditional mathematics lecturing and traditional with computer-assisted instruction. However, a significant difference was found in the scores of females and males, with females outperforming males in both modes of instruction. Descamps et al (2006) examined the role of e-learning technologies including the potential that on-line content can bring to education but they argued that this was not realized in mathematics. The materials presented are mainly formulae with some concrete and pictorial representations and interactivity is difficult on-line.

Seppala et al (2006) argued that on-line instruction is a viable alternative to traditional instruction by improving learning and reducing costs. While there were some positive results, a number of disadvantages were also noted: different learning styles, collaborative learning and discussion type instruction was not catered for online etc. It is possible that technological tools may be the answer to students’ mathematical difficulties yet studies their studies show that e-learning did not help as much for the those with weak mathematical skills and moreover, e-learning does not help much in problem solving either. Further, those with weak technology knowledge or some negativity towards technology may indeed be further frustrated and in the end not acquire the necessary conceptual understanding. Caprotti et al (2006) noted that students embraced any synchronous and asynchronous on-line learning at the university level in that on-line instruction method was a viable alternative to traditional instruction.

Smith and Ferguson (2006) studied student attrition in mathematics e-learning with data showing that e-learning in mathematics does not work as well. Student attrition was used as a measure of student satisfaction and course viability with attrition in e-learning and comparing attrition in face to face courses. E-learning recorded higher attrition with significantly higher for math courses than other non-mathematics courses. In the case of face to face courses, there were no differences in attrition rates for math versus non-mathematics. It was hypothesised that the online student populations were different from the face to face group. Some studies have noted that females are more likely to undertake online classes and they tend to gain better higher grades than males; and generally do better in the online environment (McCann, 2006; Friday, Friday-Stroud, Green, & Hill, 2006).

Smith et al. (2008) studied discipline specific e-learning that has been largely not studied when investigating the effectiveness of the e-learning course design. This study investigated how instructors of mathematics viewed e-learning when compared to other disciplines: whether e-learning met the challenges of their discipline. They found that significantly less mathematics instructors were likely to view the existing e-learning models and management systems of the time as appropriate for their discipline. Wilson and Allen (2011) also found a marked difference in the success of students taking online courses versus students taking face-to-face courses. The online students had a higher withdrawal rate, failure rate and had difficulty completing assignments on time. The students are more likely to withdraw from online courses than traditional lecture based courses (McClen, 2004; Lawrence & Singhania, 2004). But when courses are redesigned Temple (2013) noted fewer student withdrawals.

Aral and Caraltepe (2012) questioned “Does considering learning styles improve e-Learning performance?” Allowing for different learning styles indeed helps students’ understanding of mathematics but there are not an adequate number of studies on either traditional learning or e-Learning to enable reliable deductions. A small number of studies show positive outcomes but much less work has been done in the tertiary sector. Clearly, adaptive teaching methods based on learning style would tend to improve mathematics performance (Tularam & Hulsman, 2013: 2015; Temple,
Tawil et al (2012) studied students’ perception towards the importance and usefulness of modern technologies such as e-learning (WILEY PLUS) in comparison with the more traditional lecture. The sample included tertiary students who have taken mathematics and statistics. This study reveals that there is a significant difference between WILEY PLUS and lecturing. Overall, traditional lecturing was favourable in the learning process for both courses. It was the explanations, notes and assignments provided by lecturer that assisted their understanding of topics. So and Ching (2012) stated that “lessons are more interesting when blended using technological resources” (p. 10). They found student academic achievements were slightly higher in the electronic learning environment when compared with the traditional method. The e-learning approach included differentiated lessons made suitable for students at different levels. The parents were also involved in the study for they helped with homework with work continuing at home. Albano et al (2013) studied online learning in professional development of mathematics teachers. The e-learning survey results showed that e-learning needs to be well planned: tools and activities should be well designed in full detail and the scope. The focus and use of activities ought to be well stated in order to avoid “simply” participation. Thus blended learning should be fully involved using the relevant communication tools and collaborative activities if there is to be constructive critical thinking, reflection and discussion.

Tunstall and Bosse (2016) compared a traditional, lecture-based college algebra teaching with an online quantitative literacy learning method; the e-learning based on weekly news discussions as well as problem-based learning projects involving data analysis. The survey showed differences in students’ mathematical disposition, attitude, and outlook on the use of mathematics; with the online group showing favourable outcome in each, which suggests that project-based e-learning environment is a promising strategy for fostering the affective component of quantitative literacy. However, they argued that much more research is needed to capture the mechanisms through which such growth occurs. Academic partnerships (2011) note that while there is evidence that students perform as well online than within a traditional teaching setting, there are equally many studies that show little or no significant difference between both. There are studies that show that the lecturer is the more important factor in that the instructor assures multimodal learning (Jackson, 2014; Walker et al, 2011; McCann, 2006); in which there is much student and teacher interaction (Bidaki et al, 2013; Abdous and Yen, 2010) within the teaching and learning process. It then seems that an effective teaching may be the most important fact no matter which delivery or teaching and learning method is used. Temple (2013) noted the blended type flipping classroom teaching and learning methodology together with quick student feedback on assessments led to much less lower grades and similarly low withdrawal rates from courses. The students tended to take less attempts to pass and were well satisfied with courses they took.

In case of the distance learning studies, there is also the sense of isolation or low level of self-directedness (Hanover Research Council, 2009). It also noted that the online teaching of the master’s level courses have increased greatly with the business and education programs being most popular (Academic Partnerships, 2011). But some studies have showed no significant difference in student performance between the methods, rather the GPA had a significant effect on exam performance (Trawick et al., 2010). This suggests students need to be much more prepared before choosing a particular course for themselves.

In the end developments such as skype and various novel conferencing systems have all helped e-learning case. While the nature of the personal interaction between instructors and students has increased there is much increased demand on teachers or lecturers to develop new ways to present notes etc. and to become facilitators or coaches rather than lecturers. Moreover, the attrition of online
Mathematics students was found to be significant while in the traditional case, students did not in the end perform significantly poorly. It is true that the most effective on-line content is expensive to produce and much funding is required but there is a great lack of it particularly at the tertiary level. There are some such as Descamps et al. (2006) who argue that e-learning may become another fad and in the long run may not improve the teaching mathematics. However, they do agree that student education without the information networks is not possible in 2016 and that students expect all equipment “to work perfectly” all the time (24/7). There will indeed be much need for redesigning of mathematics and statistics courses given the existing learning systems may not have been appropriate for learning; although ipad is now available it again will require lecture type of teaching. There are indeed a number of hidden curricula that is taught at universities that will be left out in online teaching such as socializing, and being with fellow students, studying diversity, discussing work in face to face interactions and networking etc. It can be argued that each aspect of online technology may need further investigation and research for there may be issues unique to each aspect of e-learning if it is to be an appropriate alternative.

4. Discussion and Conclusion

The studies have clearly shown that the e-learning option is more popular when compared with traditional classroom learning but there are many studies that show not so significant improvement findings or even no difference between the two methods as well. The studies show a number of advantages and disadvantages with several issues highlighted such as: discipline to discipline differences, lack of “real” interaction and collaborative learning opportunities, gender differences as females may favour online learning, differing personal learning styles causing difficulties in both cases, isolation factor particularly in distance learning, lack of student preparation for online study, or inappropriate choice of online courses, withdrawal rates from online courses are greater than traditional ones, nature of student self-directedness and motivation levels, fear of or inadequate knowledge of the tools of technology - frightening off many to use online courses are just a few important ones. For example, the students who require flexible schedules, independent work environments, and possess strong motivation levels prefer e-learning method. However, when students value real life explanations, hardcopy notes, “real” interactive discussion and conversations with others during learning or solving problems, the traditional method is appropriate.

The mathematics discipline has problems with both e-learning and traditional methods. The online students tend to be older and perhaps working more hours than others who are full time. But many students may have had long break from studies and due to the gap in mathematics knowledge find learning problematic; the cumulative nature of mathematics knowledge lead to large gaps in knowledge and such difficulties are not able to be effectively solved online. In mathematics, good quality online mathematics courses with appropriate learning and assessments tools are difficult to develop without funding, whereas the course can be easily delivered and monitored using computer technology by a teacher as it is in online videos for example – however, the many hidden aspects of interacting live with students is then lost of course; an expert teacher who uses computer based material to impart knowledge may be less costly and more effective in a blended learning model for example.

The above difficulties with mathematics teaching exist because if it did not there would be no need for traditional schooling at all for all could be done at home; all necessary education materials would be online, from even late child care primary through to tertiary. Importantly, also, presently, there would be much evidence of deep student learning and other significant improvements more generally; given that computer technology enhanced teaching methods have been around for more than 20 years and have been extensively used in institutions. The critical review suggests that let alone the content of a course, a student must now learn both the mathematical content and technological knowledge. Also, the student learning should be done in both independent as well as collaborative discussion working environments with appropriate allowance for learning styles. Therefore, we cannot assume simply the application of technological and online methods involving mathematical problem scenarios should or will automatically lead to the acquisition of a deep or structural understanding of the content or appropriate heuristics as is required in mathematics (Tularam,
2015). Rather what is presently noted is that many students (particularly those who are marginal students) try and use internet to solve their assignment problems. Although this is commendable and encouraged, what is noted is that most of the students’ work is simply a copy from the net; and the same students are unable to explain any of their written work when questioned (Tularam, 2015).

When technology is used in mathematics via e-learning, students require much general problem solving knowledge to be successful in learning. It seems that the weaknesses noted in e-learning is of the same order as in other learning methods suggesting that there is no “one best method” of learning; in fact this is due to the complex nature of learning and teaching processes in that learning is adaptive, evolving and often not predictive (Hulsman et al, 2011, 2013). During problem solving there are multiple entry points and multiple heuristics but students often do not necessary rely on any of these, and even if they do students tend to be rather tunnel-visioned following a particular heuristic (not choosing another even when it fails to provide insights into the problem). Even when the students change to another method they often return to the earlier ones due to familiarity. Student “emotions” appear to be of major importance and therefore “only when students are simultaneously strong in both mathematical content and technology do both aspects truly enhance the other”. In other words, learning from online is as difficult as learning from any other mode of delivery of mathematical content.

Both e-learning and traditional teaching provide opportunity to engage, problem solve, persist, but with probably varying levels of success dependent on learner emotions, motivations and styles. While the e-learning can provide students with differentiated individualized work that are appropriate to their needs; the traditional can provide the opportunity self-evaluate, collaborate, and discuss or question self-understandings with friends or teachers. In this way, the modern lecturer’s mind frame may essentially remain the same but may involve adjustments to teaching. On balance we need to retain natural learning environments that allow personalized instruction but equally the traditional classroom learning where collaboration and social and group understanding can occur. The internet provides opportunities for discussion and collaboration but Quigley (2012) said “the internet limits opportunities for young students to develop social interaction skills that are critical to their overall emotional and social development” (p. 749). While young students may not have appropriate self-reflective abilities as the older ones, both groups tend to be more attentive in e-learning environments. Critically, however, this does not directly imply that mathematics learning is taking place even when some gains in routine academic testing may be noted. Students need to learn to be metacognitive -reflective and evaluative of their efforts as well as of others; also being able to identify errors in logic, typing, arithmetic etc. in solutions, which tend to be done more effectively in reading mathematical work as it is a language in itself which has to be mastered. These tend to be more effectively done in traditional learning contexts.

The social engagement and working to solve problems with peers help in the longer run for students to learn to cope with the pressures of real work environments. The e-learning environment does not effectively allow for the above. Rather, the e-learning banks on the independence and self-motivation of learners, whereas attending tutorials and lectures tend to focus students (particularly first years) to meet and socialize in the learning process. Although some real interactions do occur in teacher emails or on skype discussions these are not considered “real” interactions or face to face interactions that teach students the hidden curricula of universities as schools are for younger persons. It is noted that real “emotions” also play a part in learning and problem solving process and in mathematics for example, emails do not provide appropriate communication platform of this aspect; not to mention where typing of symbolic details often requires a lot of time etc. presently.

A US (Common Core Standards state from Engage NY, 2014) study did note that “students engage in rich and rigorous evidence based conversations about text” (p. 1) but this aspect is particularly discipline specific. There are difficulties with learning styles, with low levels of attentiveness, and low self-directedness as noted in e-learning. Students will need to take on self-responsibility for decisions about what and how they are to learn but each of these can be equally learned in traditional classes. Often students will need to become familiar with the varied technology devices, such as Matlab, SAS, Mathematica, SPSS, skype, message banks, smart phones etc. in order to be an active participant but this does take much time and often in a personalized
instruction manner. In the end, learners will need to seek and learn to enjoy discovery, which is almost always done better in social or traditional learning contexts (Bryan, 2015). What the literature shows is that learning should at least become flexible with the availability of technology and e-learning methods but most importantly, educators should focus on how to improve student outcomes in mathematics, science and engineering (Jackson, 2014). But there are also the questions about whether some students are simply not prepared for the choice they make thus setting themselves up for failure. There are questions such as should the students be restricted from taking online courses if they have not reached a certain GPA? Or should students who fail or withdraw from an online course be required to take to traditional courses? A higher withdrawal rate, failure rate and incompleteness of assignments by the deadline occur online yet students’ academic achievement, engagement, and positive behaviour were noted in the e-learning environment. Students tended to be more attentive and on-task as well as engaged within an e-learning environment. In contrast, in traditional environment student also showed good academic achievement but with a reflective, evaluative, and deeper understanding with constant persistent effort within the traditional environment and these were more related to their social learning, interactions, networks, friendly collaborations etc. Clearly, these cannot be claimed to during independent e-learning at least presently.

In conclusion, the critical review suggests that teachers should use computer assisted instruction software and realize that the novelty will wear off novel after initial student motivations. The process of learning e-learning may also become as mundane as traditional teaching and this has now noted in modern classrooms around worldwide. So the computer assisted learning may be more a supplemental tool for teaching. Yet whether the delivery is done face-to-face, online, chat, texting, or discussion boards etc., the continued success of students with marginal cumulative GPA’s shows personal contact with lecturers as particularly important regardless of the method of delivery but there is a need for much more research.

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Journal of Educational Technology, 21(3), 323-334


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International Conference on Engineering Education and Research 2016, Sydney, Australia
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