Running Head: Framing a STEM Issue – Annotated Bibliography

Assignment 1:

STEM in post-secondary education can be engaging or boring;

It is the instructor’s choice

Word count (2,000 – 3,000 words): 2,747 words

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ETEC 533: Technology in the Mathematics and Science Classroom

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**Introduction to the Issue**

The lesson one and two activities in ETEC 533 identified a common theme for me around how the use of technology (educational and industry specific technology) appears to have a positive impact on student engagement. After watching the video on clicker use in the lecture classroom, I became interested in both, but I was not aware of how they were connected. After spending some time doing a preliminary search through the literature, I became quite interested in some research that documents with evidence that there is truth to the notion that large first year science classes are there to weed out the week students. Other articles talked about how to make these classes more engaging and interesting for the students. It became evident that it was the instructors choice to make them engaging or boring.

STEM education in post-secondary education is a different world for students coming out of high school with aspirations to be scientists, engineers, technicians and mathematicians. First year STEM classes are large, lecture based, impersonal and quite often are the “gatekeeper courses” to weed out the weak so only the true scientists and engineers rise to the top and continue in these disciplines. Reliance on this method is common at post-secondary’s and it works as there are high attrition rates in the first two years of these programs attributed to lecture based courses with no engaging pedagogy that result in superficial learning, memorization and no conceptual learning (Gasiewski, Eagan, Garcia, Hurtado and Chang, 2012). This approach is more prevalent in STEM programs whereas faculty in non-STEM fields use pedagogies that encourage reflective, integrative and higher order learning more frequently (Laird, Sullivan, Zimmerman and McCormick, 2011). It does not have to be this way; it is the instructor’s choice. Gasiewski, et al (2012) has shown that instructors can encourage students to be more engaged and confident when they provide a classroom environment of openness to student questions and by recognizing their role in helping students succeed. Student engagement and openness can be achieved for example with the use of clickers in large first year science classes and smaller second and third year science classrooms (Terrion and Aceti, 2012; Milner-Bolotin, Antimirova and Petrov, 2010). A review of the contemporary literature on clickers demonstrates a general agreement that clickers encourage student engagement and interest in the classroom; however assessment of student knowledge with and without the use of clickers generally does not show a significant advantage of using clickers.

**Selected References: How they were selected**

A search for relevant literature was conducted through the University of British Columbia Library offsite, through a Cisco Virtual Personal Network (VPN) connection in January 2013. The following search terms were used in different combinations: student engagement, technology, clicker technology, STEM, education and engagement. In addition, the references of some articles that were related to the subject were viewed for relevance.

Approximately 10-12 articles were scanned to determine a selection of four that identified the problem of lack of engagement in post-secondary STEM classrooms and those with a solution through clicker technology. Further selection was done to include different perspectives: those related to STEM in general and some related to the science classroom and finally, articles were selected that were published in different Education Journals: Journal of College Science Teaching, Peer Review, Research in Learning Technology and Research in Higher Education.

**Annotated Bibliography**

Gasiewski, J.A., Eagan, M.A., Garcia, G.A., Hurtado, S. & Chang, M. J. (2012). From Gatekeeping to Engagement: A Multicontextual, Mixed Method Study of Student Academic Engagement in Introductory STEM Courses. *Research in Higher Education, 53*(2), 229-261.

The authors wanted to gain a better understanding of student engagement in introductory science instruction. They believe that the primary reason why students switch out of science majors is due to a lack of academic engagement. Their research design included a survey of 73 introductory STEM courses across 15 US colleges and universities resulting in a sample of 2,873 students. They found students were more engaged when the instructor created an open environment towards student questions and when instructors recognized their role in helping students succeed.

This study gathered quantitative and qualitative data and in the analysis, the authors presented the quantitative data backed up with qualitative information from student interviews. This was a broad based study that involved a wide spectrum of STEM courses designed to see if any particular STEM disciplines stood out from the others. There were two deviations; students with higher grades in high school chemistry were academically more engaged in introductory post-secondary STEM subjects then those with higher grades other STEM high school subjects. The second deviation was pre-med students who reported higher levels of engagement in their science courses then their peers.

Some major findings and conclusions are presented here. Students reported significantly less engagement in predominately lecture based courses. This was backed by the quantitative data were these courses were described as “mind-numbing lectures” leaving them unengaged and unenthusiastic about the course. It was found that the subject matter or the lecture format alone was not necessarily the problem, instead it was the lecture in combination with the professors own engagement that highly impacted students’ engagement. The authors suggest that raising the level of student preparation in high school science, may not improve STEM degree completion unless faculty engagement behaviours and attitudes are improved. They make suggestions to help faculty engage students are to employ more active learning pedagogies, use learning strategies that offer immediate feedback, ensure students grasp the material and make use of new technologies to help illustrate the concepts.

This is a baseline article that outlines the problem of low student engagement in post-secondary STEM courses that in turn leads to students leaving STEM majors prematurely. It also alludes to the gatekeeper, low engagement Professor as the reason for this problem and suggests that it does not need to be this way. The majority of students who can connect in some way to the Professor through engagement are more likely to stay in STEM majors.

Laird, T. F. N., Sullivan, D. F., Zimmerman, C., McCormick, A. C. (2011). STEM/Non-STEM Differences in Engagement at US Institutions. *Peer Review, 13*(3), 23-26.

The authors of this study report and expand on a previous study by one of the authors: Nelson Liard (Nelson Liard, et al 2008). They found it sobering that statistically in US post-secondary institutes, that STEM faculty use pedagogies that encourage reflective, higher order and integrative, learning less so than in non-STEM disciplines. Also, senior students in non-STEM disciplines reported experiencing more “deep approaches” to learning than STEM majors. This study defines deep approaches to learning as: higher order, integrative and reflective learning. The authors of this study looked at a survey data from 2008 of 614 institutions and selected over 27,000 seniors from STEM fields to compare against 46,000 seniors from arts, humanities and social science fields.

Overall they found that when the colleges and universities were grouped by Carnegie classification, the lowest scores for deep approaches to learning and additional measures of engagement were for research, Doctoral/Research and Masters S institutions. Institutions classed as Master’s L, Master’s M and Baccalaureate Diverse achieved mid scores and the top scores went to Baccalaureate Arts and Science institutes.

The authors conclude that the results are discouraging overall for STEM education as they did not find one institution where the scores for integrative and reflective learning that were the same or higher for STEM majors compared to non-STEM majors. However they did find some positive trends. When the institutes were ranked, the top 100 institutions had minimal differences between STEM and Non-STEM for higher order learning and student-faculty interaction. This indicates that deep learning and engagement can be improved in STEM majors to equal those of Non-STEM disciplines.

This article builds on Gasiewski et al (2012) providing evidence that STEM courses are not as engaging as they could be, and are less engaging than Non-STEM courses. When students are driven from STEM majors due to boring unengaged lecture formats, they go to non-STEM majors and they probably find these courses more comfortable even though they were not their first pick because of the deep learning and engaging environment they offer, as described by Liard et al (2011).

Terrion, J., L. and Aceti, V. (2012) Perceptions of the effects of clicker technology on student learning and engagement: a study of freshman Chemistry students*. Research in Learning Technology, 20*(2), 1-11.

The authors of this study wanted to build on the literature supporting the use of clickers as a student and instructor engagement technology. After a brief review of the current relevant literature, they discovered a gap to explore further. They conducted their study on a single 200 student first-year chemistry class and they examined the perceptions of student use of clickers to answer three key questions: do students perceive that they are more engaged when using clickers, do students believe clickers help them to learn more effectively and are students more engaged with their learning experience when clickers are used in the classroom. With these three questions, they set out to determine if there is a significant relationship between student engagement and the use of clickers.

After examining demographic factors, they determined that the student’s year in university, age and gender had no significant relationships with the three research questions. They found the following results: strong correlation between student engagement and clicker use, moderate correlation between the use of clickers and students ability to learn the course material and a strong correlation between the use of clickers and being more engaged in the learning experience. Thus the students reacted positively to the integration of clickers into their chemistry class and further, the students perceived that this in turn enhanced their engagement and learning.

With this information, the authors agree with many others in the literature that faculty behaviours influence student engagement and suggest faculty need to be aware of making pedagogical choices that encourage engagement in the classroom. Even though clickers are designed for use in large classes, the authors see no reason why they can’t be used for classes with 50 to 500 students to communicate directly with the professor. This permits the instructor to respond to the class when concepts were not understand and allows students to assess their knowledge of concepts individually and compared to their peers. The authors support reports from other studies that state clickers move the student role to active contributor from passive observer, that students come to class more prepared by completing readings and they come to class ready to participate and pay attention.

They conclude further, that the more informed, active, prepared and participating students as described above, are more motivated and overall more engaged. Finally they conclude and agree with the literature that the clicker is just a classroom technology that instructors can use to integrate into their pedagogical practises to improve student learning.

 This article presents a solution to the problem of lack of engagement in the post-secondary STEM classroom. It is targeted at chemistry, a single specific STEM discipline. It could however be used as a potential solution to many other STEM disciplines, even engineering as Terrion and Aceti (2012) hinted is the most heavily lecture based discipline of all STEM areas. Like the other articles that present the problem, they all point out that it is the instructor that makes pedagogical choices to make their lectures boring or engaging.

Milner-Bolotin, M., Antimirova, T. & Petrov, A. (2010).Clickers Beyond the First-Year Science Classroom. *Journal of College Science Teaching,* *40*(2), *14-18.*

The authors in this study wanted to look at the use of clickers beyond introductory science courses to see if they have a purpose in smaller second year and higher level courses. Their sample was very small, limited to 25 students in a second year physics course. This study, like the chemistry study by Terrion and Aceti (2012) is limited in it did not have a control group to compare data. After reviewing the literature, the authors discovered an extensive body of knowledge on clicker use in large introductory science courses, but little research on science courses in year two and beyond. They set the following key study goals: demonstrate that a clicker-enhanced pedagogy is useful in a small upper level physics course, collect instructor and student feedback on clicker usage in this course and to identify potential clicker-based pedagogy beyond the first year.

The study used the modified peer instruction method based on the work of Mazur (1997). It entails the instructor asking a question and requesting the students respond via their clickers. The distribution of student answers is displayed, but not the answer. If the majority get the answer correct, then the instructor moves on after a brief explanation of the correct answer. If the majority get the answer wrong then the instructor asks the students to discuss the question with their peers then vote again. The instructor follows up with a group discussion as to why the correct answer is correct and why the other answers were wrong to help the students develop a deep conceptual understanding of the problem.

Results from this study show that there is a statistically significant increase in students selecting the correct answer after the second vote. There is an added benefit to this pedagogy in the teacher can circulate around the room during the discussions helping the students by asking leading questions and helping students clarify concepts. The authors surveyed the students about their attitudes toward clickers and their perceptions of clicker effectiveness. Seventy percent said that they would recommend the use of clickers beyond first year because they find them helpful. Other student comments include “Use of technology makes lectures fun, like the use of clickers. It is motivation to attend class, discuss the topic and get feedback”( p. 16) and “Clickers should be used beyond first year because they help prepare for midterms, provide feedback for the teacher and the students, are interactive …..” (p. 16).

The authors are convinced that a clicker-enhanced pedagogy is a good thing and an effective educational tool for science classes in year two and beyond in post-secondary education. This article builds on the previous three providing a solution to instructors to get away from the boring, non-engaging lecture intensive format that STEM education is known for.

**Conclusion**

Clickers are a classroom technology that when integrated with an engagement pedagogy, can be used to effectively break up the intensive lecture and provide feedback and engagement for the students. If used with a modified instruction method then students can discuss difficult concepts and then respond back to the instructor through clickers to validate that they are developing deep conceptual understandings of simple or complex STEM problems. This paper has allowed me to validate my thoughts on clicker usage in the classroom in general. In my postings on clickers I suggested that their usage encouraged engagement by both the students and the instructors, gave the instructor a reading on how well he is doing at getting the message across, let students know how well they are doing individually and amongst their peers and provided a safe anonymous environment for students to try answering questions asked in class. The research provided evidence to a perspective that I had suspected; killer gatekeeper first year STEM courses do not need to be set up this way. It is the instructor’s choice to keep them boring and inactive for the students. With new technologies such as clickers, instructors can make them engaging and interesting for the students and can create an environment for them to stay in STEM majors longer. This will allow them to make better informed decisions about STEM careers based on their interest level after first or second courses rather than bailing out early because of a bad and boring experience with an unengaged instructor, perhaps in their first semester. I am quite interested in knowing why research has shown an increase in student engagement and interest in subject matter using more engaging pedagogies does not translate into statistically higher grades for students. Perhaps the assessment tools are not appropriate to capture the benefits of deeper approaches to learning that engagement nurtures. If the assessment tools are designed to test the lower level memorization thinking skills expected from traditional lecture formats then they may not capture the deeper learning associated with higher order, integrative and reflective learning and thus not show the true benefits of the engaging classroom.

**References**

Gasiewski, J.A., Eagan, M.A., Garcia, G.A., Hurtado, S. & Chang, M. J. (2012). From Gatekeeping to Engagement: A Multicontextual, Mixed Method Study of Student Academic Engagement in Introductory STEM Courses. *Research in Higher Education, 53*(2), 229-261.

Milner-Bolotin, M., Antimirova, T. & Petrov, A. (2010).Clickers Beyond the First-Year Science Classroom. *Journal of College Science Teaching,* *40*(2), *14-18.*

Mazur, E. (1997). *Peer Instruction: User’s Manual, Prentice Hall Series in Educational Innovation.* Upper Saddle River, NJ, Prentice Hall.

Liard, T. F., Shoup, T. F., Kuh, G. D. & Schwarz, M. J. (2008). The effects of discipline on deep approaches to student learning and college outcomes. *Research in Higher Education 49*(6), 469-494.

Laird, T. F. N., Sullivan, D. F., Zimmerman, C., McCormick, A. C. (2011). STEM/Non-STEM Differences in Engagement at US Institutions. *Peer Review, 13*(3), 23-26.

Terrion, J., L. and Aceti, V. Perceptions of the effects of clicker technology on student learning and engagement: a study of freshman Chemistry students*. Research in Learning Technology, 20*(2), 1-11.