AC 2010-1473: AN OPTIMIZING LEARNING STRATEGY EMPLOYING A SELECTION OF ONLINE AND ONSITE MODALITIES TO ACHIEVE THE OUTCOMES OF A CALCULUS COURSE

Murray Teitell, DeVry University, Long Beach

William Sullivan, DeVry University

An Optimizing Learning Strategy Employing a Selection of Online & Onsite Modalities to Achieve the Outcomes for a Calculus Course

Introduction

Many institutions of higher education around the world are changing the emphasis in education to more active learning styles in contrast to the older more passive learning styles.[1,2,3] An example of passive learning would be a student listening to a lecture with little to no interaction with the professor, curriculum or fellow students. In active learning, the student is tasked with a higher level of ownership in regard to academic success. The professor actively facilitates learning through discussion, feedback and other interactive models and thus serves more as a teaching mentor and guide rather than a traditional lecturer. An example of active learning is a student providing a differential equation for a hydraulic system and then challenged to learn everything they need to know to solve it. Taking the lead from accreditation bodies, progress in a course is measured in terms of desired outcomes—skills and knowledge the student should possess upon completion. Achievement of the outcomes is then measured against performance criteria. One of the preferred methods for stating performance criteria is in the form of a rubric. The rubric is applied by the teacher to the student's body of work. In active learning, the rubric can be applied by the student and confirmed by the teacher.

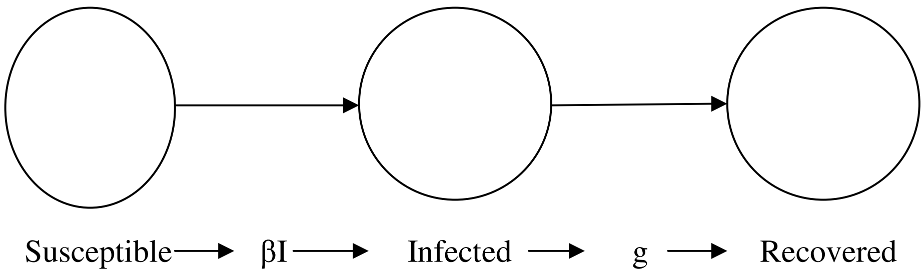
Method

This is a report on an investigation into active learning that took place in a Calculus II class taught by one of the authors. The course was complimented with an online resource shell which provided a number of resources to the student available 24 hours a day, 365 days a year through any Internet enabled (TCP/IP compliant) computing platform. The course had an established duration of eight weeks. The professor was available for in-person interaction onsite to the students for eight hours a week not including office hours. The following ground rules were established. First the students were to familiarize themselves with the resources available in the shell. Second the students were to review the outcomes specified for the course. Next the student was to start the course by stating a framing question[4] ("The Frame") which becomes the student's personal mission statement for the course.

The framing question was most important. The question cemented the commitment of the student to the course. Why was the student taking the course? What did they want to get out of the course? Guidelines were developed by the authors. These guidelines were communicated to the student on how to author the framing question. One of the predominant guidelines was that "The Frame" had to encompass all the outcomes for the course and had to empower the student to use all the available resources. The student was required to iteratively submit the framing question to the professor who critiqued it and returned it for revision. The question was to be resubmitted until the question met the guidelines and only then could the student begin to venture into the other aspects of the course. The beginning of active learning in the Calculus II course was defined as the point when the student posed the framing question in a comprehensive nature which is unique and related to the course and to the academic and career goals of the student. This began the active learning process.

An example of "The Frame" is illustrated in Figure 1. The student has an interest in how diseases spread. The student's career goal was to go into a biomedical field. The student researched the process and found a set of differential equations that model the spread of disease for a particular and general case.[5,6]

Figure 1. "The Frame" utilized in the context of the spreading of disease.



β = transmission rate, B = birth rate, d = death rate, R_0 = reproductive rate (rate that infected persons cause new infected persons), g = recovery rate, S, I and R are the populations of the three groups.

For example the differential equations can be of the form:

$dS/dt = B - \beta SI - dS$

$dI/dt = \beta SI - gI - dI;$

$dR/dt = gI - dR;$

$R_0 = \beta/g.$

What does the student need to learn so they can understand this disease process? In effect the student establishes the answering of this question as their personal outcome and challenge. For example: can the student solve differential equations that model the spread of disease? One aspect of the framing question is that it should imply all the topics associated with the course and it should avoid limiting assumptions and ideas. The following categories of framing questions were derived by the authors and are represented in Table I:

Table I: Framing Question Categories

Category	**Method**
Equations to find the solutions	linear, differential
Problems to find the solutions	find cause, find result, determine process
Geometries to understand	Euclidian, solid
Data to understand	student trends, social trends, technology trends
Statistics to understand	census, surveys, epidemiology
Actions to understand	work, tasks, forces, operators
Plans for process	organize, collect, itemize, group, sequence

The next step for the students in the course was to choose an available resource that will help answer the question. The students had a number of available resources which the university provided. The resources that were available were the professor, the textbook and in addition the online resource shell containing threaded discussions[7], online lectures, tutorials, homework assignments, assigned readings, exploration projects, library research, role-playing exercises, and online depositories for works and electronic portfolios[8]. There were also pretests[9] and practice tests which are considered resources but were also in the assessment category. The student can take a pretest and if satisfied with the score, submit it for evaluation.

Framing question ⟶ Pretest ⟶ Evaluate Pretest ⟶ Select Resource

As an alternative, the student can use the pretest as a resource for determining the level of their current understanding. Practice tests can assist in preparation for assessments. The available resources could be used to find additional and further resources. One of the suggested resource methods was for the student to ask the professor a pointed question. The professor would then answer the question and offer explanations and then suggest further resources. The student in the disease example needed to focus on differential equations. Potential approaches to the disease example were to start with the tutorials, the lectures or to ask the professor to provide a resource dedicated to differential equations. The resources indicated in Table II were available in the Calculus II course:

Table II: Available Resources

Resource	**Method**
Peers and Faculty	Discussion
Prepared Lecture	Study
Online Tutorial	Interaction
Homework assignment	Completion
Laboratory assignment	Completion
Readings	Study
Project	Completion
Project	Proposal
Role-Playing exercise	Participation
Faculty Guidance	Solicitation

When the student finished accessing the resource, they had a mandatory assessment requirement. Assessments could take many forms. The common feature in each assessment is that the student demonstrates a performance related to the outcomes and that the performance can be evaluated. The performances were recorded (written, video, audio, animation, simulation) or observed by the professor and student peers. An example of an outcome in the course is: Given a function, find the Laplace Transform by direct integration. The assessments used in the course are shown in Table III. This assessment was created by the authors.

Table III: Assessments

Assessment	**Method**
Pretests[9]	Pretest, practice tests & self-assessment – may or may not be recorded or communicated to instructor.
Quizzes and Tests:	Multiple choice, problem-solving, proofs, derivations, essays, short answers.
Written Reports:	Library research reports, laboratory reports, Paper on original proofs and derivations, homework solutions, project reports, role-playing transcripts, online portfolios[9]
Oral Reports:	Slide presentations, speeches, white board presentations of proofs and derivations and solutions, question and answer sessions, and oral examinations.
Demonstrations:	Project demonstrations, applying equations to data, and analyzing real-time data using programs
Animations and Simulations	Create computer animations and/or simulations of the phenomena e.g. periodic function, growth, expansion, and contraction.
Performances:	Video oral presentation, proofs, derivations, and solutions.

When the assessment was finished it was evaluated against a rubric. Rubrics[10] provide a clear descriptive explanation of the reason for the grade. This is more informative both to the instructor and the student. It provides a logical method to match the performance of the student to the criteria. Rubrics were created by the authors and applied in the Calculus II course. Both the student and the professor applied the rubrics and compared their respective individual decisions. Conflicts were discussed and adjudicated. The goal was to have the student and the professor in agreement either before or after further discussion. An example of a rubric utilized is given in Table IV. This rubric was created by the authors.

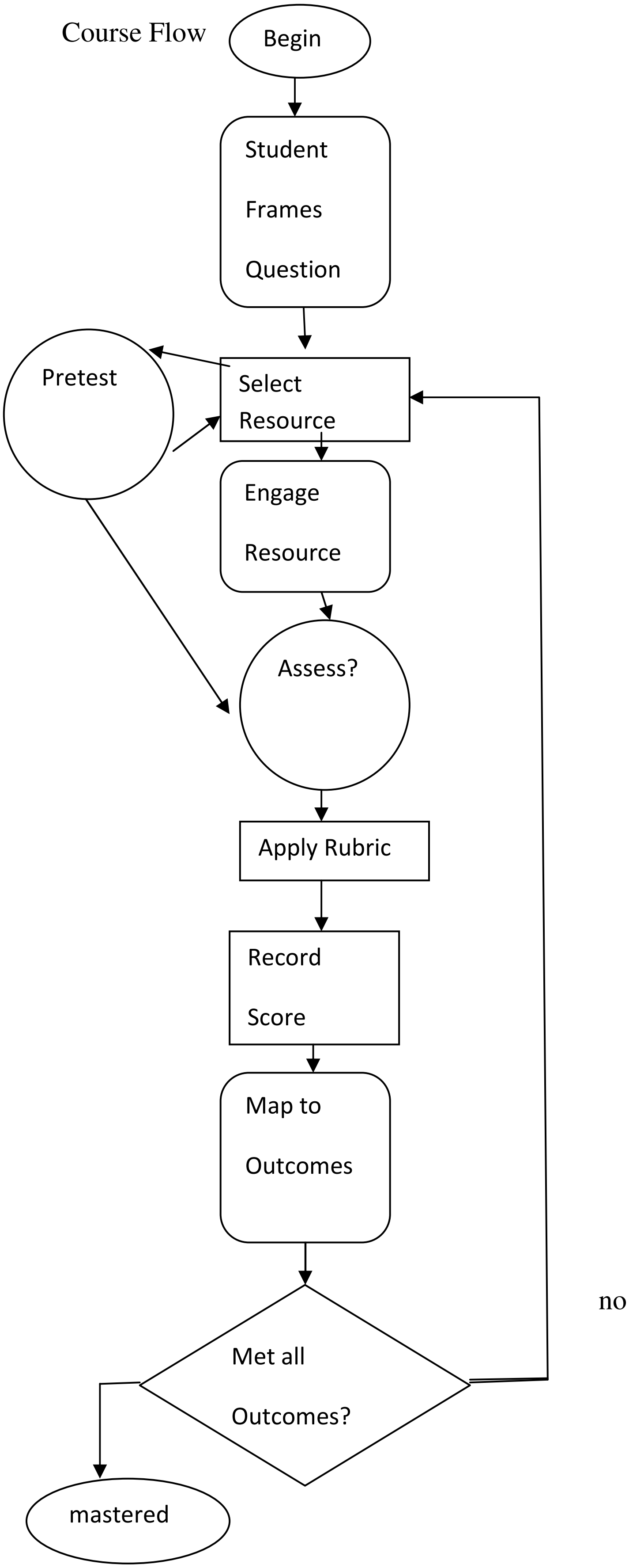
Table IV: Rubrics.

Outcome	Trait	4 Exceeds	3 Meets	2 Progressing	1 Below
Applications of Integration	Exponential decay	Provided detailed equations leading to solution. All parameters explained	Provided equations leading to solution. Some detail missing. All parameters not explained	Incorrect equations provided. Errors in derivation and detail. Incorrect solution.	Equations and derivations are totally inconsistent and are not a solution.
Use of Fourier Series	Expanding series in trigonometric form	Expansion complete, in detail and correct.	Expansion has some errors, some detail missing, and only partially correct.	Expansion has many errors, lacks detail, and faulty.	Expansion is totally wrong, inconsistent, and not correct.

Each outcome has several traits. If the performance of the student on the last assessment is below the acceptable level for the combination of the professor, the university and the student then the student proceeded to select a new resource for the same outcome and the same trait and repeat the process. A flow diagram illustrates the process in Figure 2.

Figure 2:

Course Flow



Completion

Ultimately the goal was to have the student evaluate their own achievements against the rubrics and justify it to the professor. Thusly, the responsibility for the success of the outcome increased for the student. In order to deliver the course in an orderly fashion and on schedule, deadlines for progress reports were set. This included the creation of electronic portfolios to record written work. The end result observed was that the students focused on achieving the outcomes and were able to achieve them at a higher rate.

What are the outcomes of a course and who decides them? The professor or another educator or a curriculum specialist recommends the outcomes and announces them in the syllabus. The syllabus provides a guideline or gives a roadmap on how to achieve them. The roadmap, however, can include flexibility to the instructor and the student to employ alternate routes to achieve them.

In the course, the student had flexibility as to which resources and assessment tools to use. Additional resources could be sought out and pursued. Successful completion of the course dictated that the student achieve the course outcomes and demonstrate that achievement in a measurable manner. How that achievement was demonstrated could be done in alternate ways. In some venues, the student was able to choose the best resource that would strengthen their assessment.

Results

Using active learning, the professor becomes the teaching guide with the student an active player during the journey. The student is seeking the educational program and should be aware of their goals. Active learning allows the student to validate these goals while learning the subject and demonstrating their achievement of the desired outcomes.

Conclusions

This investigation showed that students can engage in active learning. Active learning provides the student more control over what they learn and how they learn. By authoring a framing question, the student has made a commitment to their goals and outcomes. This method has been observed to result in better motivation, higher academic achievement and better preparation for a career path in related fields of study.

References

1. Tang, G. and Titus, A. (2001). Promoting Active Learning in Calculus and General Physics through Interactive and Medial-enhanced Lectures. Systemics, Cyber. & Infor., 2 (1), 49-56.

2. Youngblood, N. and Beitz, J. M. (2001) Developing Critical Thinking with Active Learning Strategies. Nurse Educator 26 (1), 39-42.

3. Maggelakis, S. and Lutzer, C. (2007). Optimizing Student Success in Calculus. *Primus, 17: 3*, 284-299.

4. Huber, M. T. and Hutchings (2005). *The Advancement of Learning: Building the Teaching Commons.* San Francisco: Josey-Bass Inc Pub.

5. Matthews, L., Haydon, D. T., Shaw, D. J., Chase-Topping, M. E., Keeling, M. J., and Woolhouse, M. E.J. (2004). Neighborhood Control Policies and the Spread of Infectious Diseases. *Proc. Roy. Soc. Lond. B 270,* 1659-1666.

6. Rohani, P., Keeling, M. J., and Grenfell, B. T. (2002). The Interplay Between Determinism and Stochasticity in Childhood Diseases. *Am. Nat.* 159, 469-481.

7. Havard, B. Du, J. and Olinzock A. (2005). Deep Learning: The Knowledge, Methods and Cognitive Process in Instructor-led Online Discussion. *The Quarterly Review of Distance Education. 6(2) 125-135.*

8. Daniels, T. (2004). Linking e-portfolios to performance standards and self-assessment. *Proceedings of the Society for Information Technology and Teacher Education International Conference. 2004*, 83-86.

9. Murray, C.R. and Vanern, K. (2005). Effects of Dissuading Unnecessary Help Requests While Providing Proactive Help. In Look, C.K., Mac Calla G., Bedewed, B. and Breaker, J. (Ends), *12th Inter. Conf. Art. Int. in Ed. Amsterdam. July 2005,* 887-889.

10. Montgomery, K. (2002). Authentic Tasks and Rubrics: Going Beyond Traditional Assessments in College Teaching. *College Teaching. 50 (1) 34-39.*