Flipped Teaching in a College Algebra Classroom
An Action Research Project

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Abstract: A project to evaluate a method of flipped teaching was set up within two separate College Algebra classes. From the curricula of each, the topic of radicals was chosen as the subject to have the flipped teaching approach; this happened over two consecutive class sessions. The rest of the class content was taught in the traditional lecture style. In the week before the class sessions, the students were provided with YouTube videos specially prepared for the students to review before the classes met and with links to the related Khan Academy videos and practice sessions. In class, the students worked in teams on related problems while the instructor circulated, providing individual instruction. Each of the teams presented their solution methods to the class. The students were surveyed regarding their experiences with the digital media, the instructional links, and the applied work done in the class, as well as about their impressions of the flipped style relative to the more traditional style of instruction.

Introduction

Flipped teaching, also known as reverse teaching, inverted classroom, or backwards classroom, has become a hot topic in the educational community, perhaps more so in the K-12 range than in the college arena. In today's flipped teaching, internet technology is used to enhance learning in a course, allowing the teacher to spend more time interacting with students and helping them directly with their subject matter. In this study, the flipped teaching method was applied in a specific part of a college course offered to a specialized group of working adults. The intent was to determine what students perceive as differences, advantages, and disadvantages of the flipped teaching method.

Many colleges today are currently offering face-to-face classes on military bases. The students taking these are, for the most part, active members of the military or their dependents. This investigator teaches Mathematics classes that are core requirements for the Associate's and Bachelor's Degrees at several such colleges in Oahu, Hawaii. Over a number of years teaching many different types of students, male and female, old and young, from many different backgrounds, several observations have become apparent.

The students tend to be well-motivated toward learning, but are not hesitant to say how weak they feel about taking a mathematics course. For many, their last math course may

have been over a decade ago; in some cases, that course was taken in high school at a pre-algebra level. The math requirement is often postponed toward the end of the degree program, perhaps because of a perceived difficulty of the subject. Consequently, an instructor faces a somewhat daunting task in making the subject friendly and relevant.

Military students typically have family responsibilities and work rather long hours. It doesn't help the educational effort that the classes typically meet once a week for four hours at a time; usually these classes are on weeknights, though classes do meet on Saturdays as well. While this type of schedule might be workable with subjects from the social sciences, it is one that is fairly demanding on both student and instructor alike. Mathematics is an abstract subject that involves interpreting and solving problems using symbols and notations that are often unrelated to everyday life. It definitely helps the learning process to have students nearer to the peak of their alertness than the opposite. Absences from class can be fairly typical; it is normal, in every course, to have nearly every student miss a couple of classes because of work or temporary duty assignments.

Under these circumstances, which include an abstract subject taught in a single block to a group of moderately tired students, a fresh approach to the delivery of the instruction has appeared necessary and desirable. The typical approach in most courses has been what is called here the traditional style of teaching; this involves the material being presented in an organized manner at the whiteboard, demonstrating the concepts that underlie the theory, and doing problems. Often this is done with the students passively observing and taking notes. The instructor can give the class problems and allow them to work together finding solutions; because of the time structure and the need to complete the evening's instruction while the students are relatively fresh, this process happens more often in the second half of the class when the brain is tiring and learning is likely less efficient.

Flipped teaching has been noted as a way of changing the dynamics of the classroom. The idea is not something totally new. Instructors have always asked for students to come prepared to class; this has often involved a request to read appropriate chapters or articles. Text-based material, to some extent, lacks attractiveness and can lead to low compliance, with the educational efforts and outcomes falling short of what may be desired. Today's technologies allow for the generation of more vibrant materials that can hold the attention of the students, induce them to prepare before class, and then come to the class with some familiarity with the subject material. This can permit the shortening of the opening presentation and can get the students into a "hands-on" mode, thereby immediately engaging them. With a different dynamism, it would appear that, in the context of this project, it might be possible to observe different outcomes.

Review of the Literature

A theoretical underpinning of the flipped classroom may be found in many theories of education. These theories assert that learning is not done so much when the teacher is imparting information from the front of the room; rather, it happens when the student is an active participant in the reception and integration of information and techniques. The key assertion is that there must be activity and not passivity on the student's part.

Theorists point to two main modes by which a learner acquires knowledge. In terms of cognition, one's past knowledge and new experiences coalesce in the internalization of new knowledge. From a social perspective, collaboration and interaction can lead to discussions, the sharing of information, the development of insights and, later, skills.

Wang (2008) indicates that, while these are different viewpoints, they are complementary in that there is no one single process of learning that each student uses. While there are different styles of learning, each student may construct a different knowledge set from the same experiences. It becomes important, then, to design the instruction in such a way as to incorporate as many elements that may be useful as possible. Kirschner et all. (2004), writing in the context of electronic collaborative environments, identified the necessary relationship between pedagogy (ways of teaching the material at hand), social interaction (whereby the students collaborate to accomplish the goals of the instruction), and technology (the tools, programs, etc., used to convey the content of the course). In this project, the instruction was primarily face-to-face; so the technology used played a different role; but all three elements were in place.

Lage et al. (2000) was one of the early thinkers who applied the concept to an economics classroom. Previous work by Zappe et al. (2009), Demetry (2010), Schaffhauser (2011), and Houston and Lin (2012) provided insights into the use of the flipped classroom with mathematics instruction. If an instructor focuses on traditional lecturing methods, the class can become locked into covering the material, with little time left for working with it under supervision to get feedback. By having prepared materials, in video or Powerpoint format to be viewed by the students before coming to the class, the instructor can free up class time for higher-level learning and for developing skills in problem-solving. Team-based learning also becomes possible in the classroom. The ideal case is when all the students conduct their preparation fully before arriving. The instructor can then quickly review the principles to be mastered and can then hand out sets of problems. The Teams can them collaborate and interact, while the instructor circulates and works with individuals at their own levels. In this way, flipped teaching permits the use of many different teaching styles so as to appeal to the many different learning styles of the students. The instructor, in essence, ceases to be the owner of the lesson and becomes the facilitator. Naturally, not every such case will be totally ideal. There will be non-compliance by some students; but, as long as there is a minimum critical mass of prepared students, the flipped classroom should have a good effect.

Methods

Two separate classes in College Algebra were available to this instructor as the environment for this study. The classes were offered at two different Colleges that serve the local military community. Each course taught was one calendar quarter long. One class met on, and one met near, a military base on Oahu, for ten weekly four-hour sessions. Both curricula were similar; the courses covered rational expressions, radicals, quadratic equations, and other topics such as simultaneous equations and linear graphs. Of these topics, the subject of radicals was the one used for the flipped teaching method. All of the other topics were taught in the traditional style.

For the purposes of this discussion, the two classes are called C1 and C2. The number of students in each class was approximately equal, being 18 and 19, respectively. While there were some demographic differences between the two groups, as discussed below, their responses to the flipped classroom method were more similar than different.

C1 attended a College that had about 75% of its enrollment from the military (including military dependents) and about 25% from civilians. C2 attended a College that had its full enrollment from the military (including military dependents). The gender breakdown was about equal across both classes, with a slight edge for females because of C1. The age structure was similar in each class; of those who reported their ages, most were 31 to 40 years of age. The balance between active military status and non-military was reversed from C1 to C2; added together, though, the numbers were roughly equal.

The C1 and C2 classes differed in the times since the students had previously taken a math class. For C1, this course was the second in a two-course sequence; for C2, the course was a solitary math course in the overall curriculum. Students in C1 came into the class either from a placement exam or directly from a prior Intermediate Algebra class. For most of the C2 students, their previous encounter with a math course was over 5 years ago.

The students in each class rated themselves on their overall abilities in math, on their abilities in arithmetic, and on their abilities in algebra. Because of the similarities in these and subsequent responses of the two groups, their results will be combined from this point forward. Overall, the students were of the view that their math skills were better described as weak than as strong. They did differentiate their algebra abilities from their arithmetic abilities, feeling that the latter were stronger than the former.

For the majority of the course content, the instruction was carried out in what has been described as the traditional style of teaching. The instructor presented the material of the day to the class and worked demonstration problems. Students were then given problems to be worked, which were then commented on and explained. The subject of radicals, common to both classes and introduced about midway through the term, was taught instead with the flipped teaching method over two consecutive class sessions. This particular topic was selected because it was thought to be likely that the students wouldn't have a great familiarity with the nuances of the subject, and, consequently, they might be more aware of the contrasts in the teaching styles.

For the flipped teaching method, the students were supplied with specific instructional materials on the internet. They were notified of the locations of these materials a week in advance and were told that they were required to view and use them prior to the next class. There were two distinct sets of materials.

The first set consisted of Powerpoint movies prepared by the instructor and posted to YouTube. These movies provided sequential chunked instruction in the upcoming subject matter; the instructor was both the author and the narrator. The second set

consisted of links to the portion of the Khan Academy website where various aspects of the subject of radicals, scheduled in the courses' curricula, were covered. In the website, the short videos provided both content and demonstrations of methods. Self-assessments were available there for the students to check their understanding.

At the outset of each class in each course, the students were given a short Quiz to assess whether they had accessed the internet material during the prior week. The questions focused on aspects of the presentations they might be likely to remember and on anomalous, sometimes humorous, inclusions in the Powerpoint movies that they could not have known of without actually watching them.

Instruction in each of the radical classes began with a request for any questions on past or current materials, course announcements, and an overview of the topics of the day. After these topics were briefly explained and demonstrated, the students were provided with sets of four or five problems and were asked to form into teams of no more than four members; depending on the attendance in each class, this meant there were four or five active teams. As the teams completed the problems, a member of each team would present one of the problems at the whiteboard. A more challenging problem of the same type would then be given to the teams; this was followed by a similar presentation to the class as a whole. There were three such sessions in each class meeting; each session lasted up to one hour. There was a fifteen-minute break between sessions. The class concluded with an overview of what had been learned and with a look ahead to the topics of the coming week.

Throughout these sessions, the instructor circulated and worked individually with the teams, guiding their efforts at finding solutions and helping them with any difficulties in their conceptualization of the mathematical tasks at hand.

In the class immediately following the two sessions on radicals, the students were provided with an anonymous paper-based survey of approximately 45 questions. The survey gleaned information on student demographics, math background and skills, and attitudes about the flipped teaching method. In addition, several students were interviewed in order to get more personal responses about the educational process in which they had participated.

Results

The initial quizzes, given to determine whether the students had followed the instructions for preparing for the classes, indicated that there was a problem with student compliance. For the initial class, there only appeared to be about a third of the class that prepared, at least partially. That number increased in the following week to about two-thirds. The latter quiz result seemed consistent with the survey's self-reported numbers of those doing the requested preliminary work. Interestingly, the self-report for work done before traditional classes was practically identical.

After the demographic questions in the survey, discussed previously, the students were given a series of questions designed to elicit a sense of their perceptions of the flipped teaching method. These questions were structured along a three-point rating scale (similar to a Likert scale), with the central choice representing "neutral" or "undecided". As designed, the survey's value was for the acquisition of qualitative information only. No inferences were made or were intended to be made regarding any statistical significance of this data. The data is here taken to be suggestive only, though it may, at some later time, point the way to a more pertinently significant study.

When asked to state whether they liked or disliked each of the two teaching methods used in the course, the students seemed to be evenly divided regarding the flipped teaching method. The traditional method fared better in this regard. One might speculate here that these students have had, in most of their college courses, instruction presented in the traditional manner, and, hence, this is the norm for them. For most, if not all, of these students, the flipped teaching method may have seemed like a novelty, and perhaps, not something they would see much of again.

The students were asked to consider how well they learned in the flipped classes and to consider how their long-term retention might compare under both teaching styles. The data appear to indicate that, for both methods, it was considered somewhat more likely than not that there would be retention of some of the knowledge gained beyond one year. The traditional method seemed to be more favored in this regard. Again, a similar speculation to the one above may be in order.

The students were queried about how important each of the three instructional components (the YouTube Powerpoint movies, the Khan Academy videos, and the class teamwork) seemed tothem. Both the YouTube and the Khan Academy videos appeared to score about equally, with more students thinking of them as good than otherwise. The class teamwork appeared to be quite well-regarded, making it, for most students, the best part of the experience.

The instructor noted that, during the class sessions, the teams of students appeared to be, with few exceptions, strongly engaged in the problem-solving activities. There were, in each class, a couple of students who began working on their own, but later joined in with a neighboring team, mainly, it seemed, to compare their answers. The students in class were fairly reticent about their views of the process. The student-teacher interactions were largely focused on the solution of problems. On two occasions, though, the instructor was told that they liked this way of doing math.

The anonymous survey form provided a space for open-ended comments from the students. Some of these are reproduced here:

1. "I have spent the entirety of the class trying to catch up. The flip teaching has been better since there is exposure to the material before the class. I wish that I would have had a video and a powerpoint before the 1st class. It would have made a huge difference to have had at least a partial understanding. I think that flip teaching is a great idea. It should start at the very beginning of the course."

2. "I feel traditional and flip teaching go hand in hand. Teaching both ways at the same time will help the students prepare for traditional teaching and will be more class participation, because everyone is familiar with assignment and subjects."
3. "I enjoy the traditional method. I feel like I learn the material rather than guessing with the flip teaching. The flip teaching would be great for online students, but I prefer the traditional style."

The interviews provided several comments of interest:

1. "Q: OK. The two styles of learning and teaching. The traditional, I did traditional here today. Those were non-traditional, the last two classes, and there were traditional before that. What were your thoughts on these?
A: A good combination of the two. It gives a little change of pace and it doesn't get very redundant. Sometimes you just have teachers up there doing it; sometimes students zone out. But this will get a little classroom interaction and helps you out. It's a good balance of the two. Sometimes you have to go back the other way just to get that structure and get the point out and then you could practice the other way. So, it's a good combination of the two."
2. "Q: OK, and just a quick comparison of the two styles of teaching – the regular traditional one and the flip teaching that we did for those two classes
A: With traditional teaching, when you introduce new things, you can explain it. With the flip teaching, you see the topic beforehand, and so whether or not you really understand it, when you get in the class, it's almost forgotten as far as what the flip teaching. But what I did like about the flip teaching is it's in chunks, nice little chunks that you can review with post-class. So after having done the traditional and then going back to some of the flip powerpoints and videos, it was nice to do a review."

The main thrust of comments like these was that mixing the methods gave the most desirable mode of instruction. Clearly, some students favored one learning style over another. With a variety of students in the room, using one method may not work so well.

Discussion

This project involved a modification of a pedagogy rooted in past face-to-face math classes, but that was adapted here to the flipped teaching approach. Much of the lecturing that would have occurred in the classes was exported to internet technology, where it was expected that the students would retrieve them, use them, and, thereby, bring a different mindset to the class. The traditional face-to-face contacts were minimized in the two sets of classes making up this project, with the bulk of the course material being formulated as new YouTube PowerPoint movies and as pre-existing Khan Academy videos. Besides this blending of technology and pedagogy, there was also an important level of social interaction with the students working together in groups.

The instructor learned that, while pre-existing tools like the Khan Academy videos are easy to implement, there is a distinct advantage to putting one's own mark on the instruction by generating custom material. For one thing, the self-prepared instruction

will match more closely the teaching styles of the instructor; it might be expected that this could reduce the level of dissonance in the student who is trying to absorb different pieces of the instruction. For another, it puts the instructor into a newer relationship with the course material, perhaps giving some insights into how to better present it to the class.

In many ways, the flipped teaching method moves the classroom from a deterministic form (the essence of the traditional approach to instruction, in which cause (lecture) gives rise to effect (learning)) to a more stochastic or probabilistic form (in which the outcomes for the individuals are more uncertain and varied). For many instructors, including this one, this is a form of terra incognita, in which different things can happen educationally, many of them interesting and good. It is also a time of self-discovery, since, in the time of circulating amongst the working teams, the questions being asked and the issues being raised are always different and seemingly random.

The findings here were, in the main, positive for the flipped teaching approach, although the traditional form of teaching was far from rejected. The project was conceived as an exploration – "Let's do this and see what happens". It was clearly not a scientific research project, since it lacked the usual statistical trappings. Rather, as an action research project, it was, in many ways, an effort by the instructor to gain direct experience in some of the ideas involved with practical education.

The confluence of students, the exact mix of whom could not have been predicted, provided the raw material for the investigation. Most likely, they were typical of many such classes that continually go on; but they are variables here that are uncontrolled in the statistical sense. The procedures adopted also might have been different. Although Khan Academy is highly regarded as a model of flipped instruction (Sparks, 2011), perhaps other such sources might have been used. The approach of producing YouTube videos might have been refined in a different way, giving rise to a different, though probably similar, set of results. Possibly, the teamwork could have been more defined or made less structured. The survey used at the end might have been better designed, with more probing questions. Assessments weren't done here; but that seems like a logical next step – get some measurements to quantify in a better way what we are seeing. While the entire project might have been structured differently, in all of the above regards, there is the sense that the end results and insights would not have been far different.

Conclusions

There were some major insights to be taken away from this experience.

1. The whole course should be structured in some version of the flipped teaching style from the first day.
2. Compliance with the basic rues of accessing the course material before class must become universal (or nearly so).
3. If a change looks to be plausible, then implement it right away. This isn't, after all, a controlled experiment.

References

Demetry, C. (Oct 2010). Work in Progress – An Innovation Merging "Classroom Flip" and Team-Based Learning. 40th ASEE/IEEE Frontiers in Education Conference, T1E- 1-2.

Houston, M. and Lin, L. (2012). Humanizing the Classroom by Flipping the Homework versus Lecture Equation. Proceedings for Society for Information Technology & Teacher Education International Conference 2012. Chesapeake, VA: AACE, pp. 1177-1182.

Kirschner, P., Strijbos, J.W., Kreijns, K., & Beers, P.J. (2004). Designing electronic collaborative learning environments. Educational Technology: Research and Development, 52(3), 47–66.

Lage, M.J., Platt, G. J., Treglia, M. (2000). Inverting the Classroom: A Gateway to Creating an Inclusive Learning Environment. Journal of Economic Education, v. 31, Part I, 30-41.

Schaffhauser, Dian (February 2011). The Backwards Class. THE Journal (http://thejournal.com/articles/2011/02/02/the-backwards-class.aspx).

Sparks, S. D. (14 September 2011). Schools "Flip" for Lesson Model Promoted by Khan Academy. Education Week, 31(5), p. 1.

Wang, Q. (November 2008). A Generic Model for Guiding the Integration of ICT into Teaching and Learning. Innovations in Education and Teaching International, 45(4), 411-419.

Zappe, S., Leicht, R., Messner, J., Litzinger, T., and Lee, H.W. (2009). "Flipping" the Classroom to Explore Active Learning in a Large Undergraduate Course. American Society for Engineering Education 2009 Annual Conference.