TRANSFORMING DESIGN EDUCATION WITH VIDEO
EXPERIMENTING WITH THE FLIPPED CLASSROOM STRUCTURE FOR INDUSTRIAL DESIGN

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INTRODUCTION

Salman Khan's "Khan Academy" website has turned the method of math education upside down by using simple YouTube videos. High school classes are using the math concepts he presents in short online videos for students to watch and re-watch at their own pace as homework (Khan, 2011). This allows teachers to spend less time lecturing and more time helping individual students on problems. This teaching structure has been called the flipped (or inverted) classroom. In this structure the lecture occurs outside of the class time through technology while homework and assignments are conducted during class time (Strayer, 2007). Industrial design skills courses, such as perspective drawing, rendering, and software could use this structure to improve learning. An industrial design skill building course was experimented upon with a variety of structures and compared with previous sections taught in a traditional manner. Students were surveyed and written course evaluations were studied and compared between pedagogical strategies.

THE PROBLEM OF STRUCTURING AN EFFECTIVE CLASS

A critical part of industrial design education is to learn and practice the skills of industrial design. These skills include drawing, perspective, shading, rendering and visual communication both using analog and digital tools. Computer software, most notably Adobe Illustrator, Adobe Photoshop, Rhinoceros, Alias, Solidworks and others are important and useful tools for a professional designer. The problem with teaching such skills in an effective manner is dependent upon multiple factors:

- The variation in prior abilities among students
- The learning styles of students
- The amount of time spent in class with the instructor
- The number of students in a given class
- The speed, quality and interactivity of the skills demonstration
- The time and quality of individual critique of assignments
- Interesting, challenging and motivating assignments

These factors are based on the author's experience of teaching this course for 15 separate quarters. Many of these factors the instructor has no control over, such as class size and student learning styles. This paper will deal primarily with the demonstration and how it is conveyed, especially with teaching industrial design skills since instructor's demonstration and explanation of a skill is a key method of learning. However, no matter how proficient, patient, or eloquent the instructor may be, the demonstrations can be too fast for some students and too slow for others. Students may not hear it in the back of the room and they may feel uncomfortable to ask for repetition. Depending on when the class is scheduled some students are alert, some are exhausted, and some are ready to learn. In a typical design skills course the class session is filled with time to critique student

assignments and an instructor's demonstration. Depending on the size of the class, critique can take two hours or more, allowing only a few minutes per student, leaving even less time for the demonstration.

What makes structuring an effective class even more difficult is that each student learns in different ways. These learning styles have been categorized into dependent, collaborative, and independent learners. Dependent learners need clearly expressed direction from the teacher; however independent learners just need time to figure it out on their own, and collaborative learners learn best in a group setting (Lage, Platt, & Treglia, 2000). An industrial design class room has a mixture of these types of students, so no one teaching method is going to meet all students' needs.

THE COURSE

The course used to experiment with these methods is titled "Industrial Design CAD Skills" at Western Washington University. It is a sophomore level course that is 12 weeks long and meets twice per week for three hours per session. The enrollment is typically 21 to 26 students, but due to budget constraints in 2012 the course had combined two sections into one course of 31. It is taught by the author with no lab assistants or teaching assistants. The objective of the course is to teach four different software programs in the context of industrial design; Adobe Illustrator (2D vector rendering), Adobe Photoshop (2D raster rendering), Rhinoceros (3D CAD modeling) and KeyShot (3D rendering). It is assumed that the students have no prior practice in these programs; however the progression of skill competency is fast. Examples of assignments are shown in figures 1 and 2.

Figure 1: A concept vehicle designed by student Gary Liljebeck using Rhinoceros and KeyShot software in the course Industrial Design CAD Skills 2012.

Figure 2: A mountain bike rendering by student Mauricio Romano using Adobe Illustrator 2012

METHODS AND PROCEDURES

This course was taught in several different ways since 2004, however the major difference occurred in 2012 when on-line streaming videos of demonstrations were created and made available to students. The theory of this was that students can individually watch them outside of class time. The student then has control to rewind to repeat a point, to skip over areas that the student knows, adjust the volume or watch them at a time when the student is alert and ready to learn. This has been shown to enhance student learning and free time during the class session for more personal feedback and attention (Lage et al., 2000). The following describes the four methods used in the course structure for an individual session.

Method 1- Traditional, live demonstrations only: The first method for this course was to begin the session with a critique of student's assignments that were due at the start of class. This would take about one or two hours. This critique may involve some brief demonstrations of technique. Then, the final hour would be a demonstration of new skills and techniques and an introduction to the next assignment. No time in class was given to work on their assignment as it was expected that it would be done outside of class. No videos were made available to view.

Method 2 - On-line video demonstration only: In this class structure, the class was split into groups. One third would participate in a group critique of their previous assignment. The other two-thirds would use audio headphones to individually watch the instructor's video demonstration online and begin working on their next assignment. After an hour through the class, the groups would switch. No live demonstrations were conducted.

Method 3 – Combined: Both live and on-line video demonstration: This structure was identical to Method 1, except that the instructor's demonstrations were made available to view later through on-line streaming videos.

Method 4 –One on one critique: For this class, the assignment was due at the end of the class period, instead of the beginning. This allowed students to work on their assignment while the instructor was present and available to help. These students received one-on-one critique by the instructor while they worked. The assignment did not involve new techniques and were revisions and improvements to their previous assignment. On-line video demonstrations were also available to view at any time.

In prior courses from 2004 to 2011, Method 1 was used exclusively, with no online streaming demonstrations created by the instructor. However, students occasionally found related instructional videos elsewhere. In 2012, all four methods were used at different times. At the end of each course a course evaluation survey was taken by the students. This includes a multiple choice survey of course effectiveness and written comments. In 2012 an

additional survey was done with more specific questions on course methods, structure and the use of video. A comparison of learning outcomes is difficult because the outcome evidence is visual and not quantifiable.

RESULTS

COURSE EVALUATIONS

In order to compare course ratings from students with the different methods of teaching, six quarters of the same course were compared, from winter quarter 2009 to winter quarter of 2012. There were many variables besides teaching methods from quarter to quarter, the greatest of which was class size. Class size had increased from about 21 in 2009 to 31 in 2012. Another important variable to consider was the instructors work load. For instance, in winter of 2009 the instructor was teaching an overload of coursework and in winter of 2011 the instructor was planning a conference and doing consulting projects at the same time. Both of these events had adverse effects on teaching effectiveness.

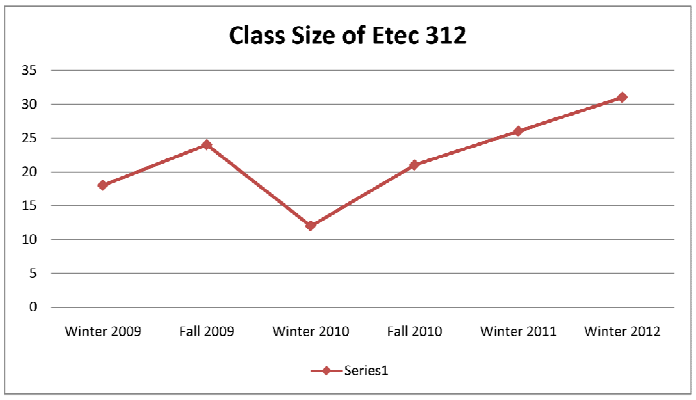

Figure 3: Class size increase 2009-2012

Table 1 displays some selected aspects of the students course evaluation ratings from each quarter of the course taught. It is listed by question and by class size. The ratings from 2009 to 2011 were averaged together since they represented teaching method 1. This average was then compared to the course ratings from 2012, which represented an introduction to teachings methods 2, 3 and 4 using online video demonstrations. The scale for these ratings is as follows: 5=Excellent, 4=Very good, 3=Good, 2=Fair, 1=Poor, 0=Very Poor. A discussion of these results occurs in the analysis portion of this paper.

WWU Etec312 course evaluation ratings	Winter 2009	Fall 2009	Winter 2010	Fall 2010	Winter 2011	Winter 2012	average 09-11	change (09-11 vs 12	effect
Class size for surveyed courses	**18**	**24**	**12**	**21**	**26**	**31**	**20.2**	**53%**	large increase
Demonstrations of expected skills were:	3.9	4.4	4.0	4.3	3.5	**4.3**	**4.0**	**8%**	slight increase
Instructor's recognition of student progress:	3.9	4.1	4.0	4.3	3.6	**3.9**	**4.0**	**-2%**	same
Instructor's availability for extra help:	3.8	3.8	3.7	4.2	3.2	**4.0**	**3.7**	**6%**	slight increase
Instructor's tailoring of instruction to varying skill levels:	4.1	3.9	4.3	4.2	3.5	**4.0**	**4.0**	**-1%**	same
Instructor's feedback regarding skill performance was:	3.9	4.0	4.0	4.4	4.0	**4.2**	**4.1**	**3%**	same
Instructor's contribution overall to the course was:	4.2	4.7	4.3	4.6	4.1	**4.6**	**4.4**	**4%**	same
average	**4.0**	**4.1**	**4.1**	**4.3**	**3.6**	**4.1**	**4.0**	**3%**	same

Table 1. Etec312 course evaluation ratings 2009-2012 for Prof. Morris.

STUDENT SURVEY ABOUT ONLINE VIDEO DEMONSTRATIONS

A survey was given to students at the end of the 2012 winter quarter. Its purpose was to gauge their learning preferences and their acceptance and utilization of the online video demonstrations. The following 11 questions were posed with the listed results:

1. It was helpful for my learning to have online videos of software demonstrations available to watch in this class.
strongly agree 73%
agree 23%
neutral 0%
disagree 0%
strongly disagree 4%

2. I learn better from online video than live in-class demonstrations
strongly agree 0%
agree 23%
neutral 50%
disagree 23%
strongly disagree 4%

3. I learn better from live in-class demonstrations than from on-line videos. (traditional)
strongly agree 4%
agree 31%
neutral 62%
disagree 4%
strongly disagree 0%

4. It is difficult for me to follow in-class live demonstrations of software skills.
strongly agree 4%
agree 38%
neutral 19%
disagree 38%
strongly disagree 0%

5. I get more out of full class project critiques (all 30 projects) than in small groups of 10 with the professor.
strongly agree 8%
agree 8%
neutral 12%
disagree 50%
strongly disagree 23%

6. I prefer to watch the demonstrations as online videos and spend class time for more individual attention. (flipped classroom)
strongly agree 4%
agree 35%
neutral 27%
disagree 35%
strongly disagree 0%

7. I'd prefer to spend less time on critique and more time on a live demonstration of the software.
strongly agree 8%
agree 31%
neutral 23%
disagree 35%

strongly disagree 4%

8. I prefer a class session where the assignment is due at the end of the class period, so that I can get help and advice during class, right before I submit it. (method 4)
strongly agree 35%
agree 23%
neutral 12%
disagree 27%
strongly disagree 4%

9. I liked having small group critiques with my classmates reviewing each other's work. (collaborative learners)
strongly agree 23%
agree 50%
neutral 12%
disagree 12%
strongly disagree 4%

10. I learn best by just diving in and working with the software, and only need help when I get stuck. (independent learning style)
strongly agree 8%
agree 19%
neutral 27%
disagree 31%
strongly disagree 15%

11. I would prefer that all of the demonstrations are only available as online videos, and class time is used for critique and individual attention. (flipped classroom)
strongly agree 0%
agree 12%
neutral 8%
disagree 54%
strongly disagree 27%

STUDENT COMMENTS

Students were asked to "write your honest comments about the use of online video demonstrations in Etec312." Following are most of the comments. Only repetitive comments were omitted for space.

"I really learned from and utilized the online tutorials. As long as all the information was there, I could replay the process or technique as many times as needed without having to worry if I missed a crucial step in class. Although, I feel that live teacher instruction is important as well because of the interaction between students and the lecture."
"It was nice to have both, rewinding with the videos was very helpful, and the ability to review things was good too, but it was nice to have some live things and be able to ask questions. I think a blend of both will work the best in the future."
"The online video demonstrations were great as reference material later on when one gets stuck working on an assignment or if you miss a class, but shouldn't replace the class lecture/demonstration."
"I think that the online videos have been helpful for basic understanding and tools, but more in-depth skills haven't been shown, particularly in Rhinoceros. That being said, there are a lot of videos out there that are helpful for these tools, so it isn't necessary for the instructor to make them all specifically for us because they take up a great deal of time to make. I do however like having the videos as a supplementation of the in-class lectures and demonstrations in case I had to miss class or missed something. As a whole I think they are definitely beneficial and should be used again."
"They were very helpful, it's easy to fall behind during live demonstrations and the ability to re-watch a section multiple times to fully understand the steps is very helpful."

"I like the online videos because you can pause and rewind. However in-class demos are valid as well because you can ask questions at the same time."
"Online videos have been extremely helpful this quarter! I think it is also important to have live demonstrations as well because of questions we may have. Live demonstrations and posted online demonstrations together are perfect, we can ask you questions at the live demonstration and if we forget something which happened regularly for a lot of us because of the magnitude of information given we can look back at the online videos and be saved!"
"They were great as a supplementary source, videos in class were better because we could ask question or ask you to redo a step. Online videos did not have that option, but were great for tips."
"I think that online videos are a useful addition to live demonstrations and in class teaching, but they do not serve as a worthy substitution… Having interactive teaching is an important aspect of any class."
"The online videos provided were great help with the homework assignments outside of our meeting time, however, I think they should be used alongside the live class demonstrations so that questions can be asked as the material is presented."
"I really thought classes that were broken up into 3 critique groups and coupled with online tutorials worked best. I got a chance to see all the renderings and tune into critiques as well as get time to learn the program and work on assignments."
"The online videos, as well as the in class lectures, were very helpful. I liked having both because I feel like I learn better through live demonstrations, but it was very nice to have videos to refer back to, especially if I missed something in the in class lectures, which tended to happen quite often."
"The online videos were incredibly beneficial. I could watch them while I was working on a project and revisit places or techniques where I had difficulty."
"I think they were a great resource. I could revisit them to see unclear instructions without having to interrupt the professor quite often with difficult programs."
"I didn't watch the online videos if we had a demo on the subject. I think I started watching them when we were required to do so for the Photoshop renderings. They were helpful but I definitely gain a lot more from the demos in class because I can ask questions. Usually the in-class demos are more in depth."
"I loved using the online videos -- they were well made -- and I used them to buttress, rather than replace, the in-class demonstrations. Ultimately, I found all of these programs to be very difficult and therefore needed to use my notes, videos, class demonstrations, student and/or your direct help to accomplish anything."
"I found these demonstrations to be helpful, because I could watch them outside of class, and spend my actual class time getting help from the teacher on things I had problems with. I do think though they should not be entirely relied upon, for the in-class demonstrations were quite helpful and informational."
"I found them very helpful, but there were instances (during live demonstrations) where the ability to deviate from the demonstration and ask related questions was helpful."
"Overall I thought the structuring of the class was very professional in its mix of work time and critique from the instructor. The only thing I would recommend is a larger amount of video tutorials and links to help the students."
"I used the online demonstrations regularly and they eventually served as a lifeline for me when I got injured and was not able to attend class."

ANALYSIS

COURSE EVALUATIONS

These course evaluations show no significant difference in ratings between the various methods of teaching the course. Most factors were statistically unchanged. The largest increase of 8% occurred in "demonstrations of expected skills." The most obvious increase was class size, which increased from an average of 20 in 2009-2011 to 31 students in 2012. Perhaps the most important accomplishment then is that the course quality didn't deteriorate due to an increase in class size. This may be due in part to the access of online videos. Variation in course ratings had more to do with professor's workload circumstances during that quarter.

VIDEO DEMONSTRATION SURVEY

Through this survey and the written comments, the message from the students was clear and consistent. The online videos were very useful and helpful, but they should not replace live demonstrations by the instructor. The live demonstrations were interactive, fluid, and in depth, but the online videos were useful when a technique was

missed or a student was "stuck." When asked about how they best learn (in questions 2, 3 and 4) the class was split. Half preferred the online videos, half preferred the live demonstrations. Half could follow the live demonstrations and half got lost. However, they all agreed that both methods should be used together.

Small group critiques were preferred over full-class critiques by the majority (questions 5 and 9). Although this seems to not be related to online videos, it does pertain to class structure, and videos allow this structure to work. The small group can focus on the critique in a more intimate scenario, while the rest of the class can work on assignments and watch online videos at their own pace. Based on written comments regarding the various methods, students valued a balance of live demonstrations, online video demonstrations, small group critiques, and time to work on assignments in class.

OTHER RESEARCH FINDINGS

These findings are congruent with other research such as J. Strayer's Ph.D. dissertation in 2007. He found that students in a flipped classroom structure "experienced more innovation and cooperation in their classroom learning experience when compared to the traditional classroom students." However they were less satisfied, unsettled and uncomfortable with the structure (Strayer, 2007). Other research findings show that while a flipped classroom structure can have benefits, it affects some students more than others depending on their learning style. The increased faculty-student interaction and more collaborative learning occurring in the flipped classroom model benefits collaborative and independent learners but not dependent learners (Lage et al., 2000).

CONCLUSION

A flipped classroom is not the ideal structure for industrial design skills classes because the effectiveness and interactivity of a live demonstration. However, these live demonstrations have limitations of only occurring once and at a set pace, which is often too fast for half of the students in the class. Making online videos of these demonstrations available to students to watch at anytime has proven very helpful and valuable to their learning. They served as support to students while they were working on their own assignments outside of class. When class sizes have increased, this mathematically decreases the time of interaction between student and teacher. However, online videos can gain some of that time back if used in conjunction with small group critiques. An ideal class structure for industrial design skills seems to be one that employs:

1. Live interactive demonstrations of skills by the instructor
2. Online videos of these same demonstrations available to watch at any time
3. Small group (6-10) critiques involving the instructor and peers
4. Time to work collaboratively on assignments during class
5. Challenging and motivating homework assignments.
6. A changing structure that addresses variety of learning styles

Although this is not a traditional structure, it is not a "flipped classroom" either. It is a blend of a variety of techniques that is adjusted from day to day. The adjustment of structure addresses the varied learning styles of students and it also provides a change in routine. Early in the course, more live demonstrations will take precedent due to the need to learn new techniques. Later in the course progression, more time can be allotted to critique and interactive work during class time.

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