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Development of an Open-Source Concurrent Enrollment Course that Introduces Students to the Engineering Design and Documentation Process

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I currently teach Design Engineering courses at both Fremont and Bonneville. I also teach Driver Education for Fremont High, as well as mathematics and interior design courses for BYUI, architecture courses for Weber State University, and graduate level courses in Business and Education for Argosy University. I am currently the president elect for the Idaho Life-long Learning Association in my spare time.

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Abstract

The technology used to generate mechanical drawings has evolved significantly in the last few years. The CAD (Computer Aided Design) software not only provides fast and efficient tools to generate these mechanical drawings, but provides tools for design review and evaluation. The designer of today must understand the design intent and constraint requirements of the part and/or assembly being created. It is critical that these concepts be incorporated into the existing drafting and design course without neglecting the fundamental concepts traditionally taught in this course. Time in the classroom remains constant but the content has increased to include the use of software. Although the technology has evolved significantly, the fundamental principles of drafting and design have not changed. This course was designed to cover the fundamental concepts of drafting and design while incorporating the forward thinking and preplanning of the part and/or assembly required by the new CAD technology.

In general, the drafting and design world has undergone drastic technological changes. These changes have had a huge effect on technology and engineering education. The course objectives and assessments at the state level has been a subject of discussion for several years, particularly because of the fast pace change in technology and how it is reshaping the industry. This presentation/paper will explain how the use of online course content and the flipped classroom model was used to increase the amount of material presented in the classroom and enhance the learning and understanding of the student with applied skill development.

For the purpose of this course the Curriculum Development Team was composed of selected instructors from across the state to create a web-based book (Portable Document Format and/or eBook) and online course that teaches the principles of drafting and design at the process level to promote curriculum acceptance and implementations from K-12 to Post-Secondary Education. The team members of this project were given the task to teach the underlying basic principles of drafting in generic terms and then supply some supplemental training specific to each CAD software package. This approach treats the specific CAD software as just a tool to learn the process so the student can solve the problem much like a calculator is to math (just a tool, it does not matter if it is a Casio or an HP). The knowledge and application assessments will be process based, not based on specific software. This will provide some freedom or variety between the USHE programs attempting to supply students that are more specific to a certain industry. The team members see this proposal as an opportunity to help solve this problem.

One of the major contributions of such a curriculum is that the book will be accessible as online course, which is in accordance with the current state objectives for both the pre-engineering and drafting technology programs. This is unique as this method will provide consistency in content in every school in the state. In other words, every school within the State will be using the same book, objectives, and outcomes for a concurrent enrollment class accepted by every state college/university. There are several benefits for both schools and students while using this online book. One, it will provide information early enough (via a link to higher education path) to those students who are keen to enter a career in an engineering profession early in their education, regardless of their geographic location. Two, this book focuses more on the process therefore concern about the contents being out of date is not an issue. Three, although CAD software is required for this course, however, each lesson applies techniques and skills that are

not dependent on the version of the CAD software and any version (release) of that software. The book will be accessible through online course delivery. The entire course was developed around the state objectives for both the pre-engineering and drafting technology programs.

Introduction

The acquisition of drafting skills is developed through instruction and practice with continual encouragement for the student to develop speed and accuracy in their drafting. The development of drafting skills requires time, patience, and effort to develop and master[3]. Unfortunately adequate time to master the needed skills is often not available in a high school classroom setting. Today, with the introduction of computer aided drafting software, students are losing important basic skills. Research shows mixed results about this. Some researchers say that the way to train students is to teach only CAD drafting skills[5]. Other researchers present the argument that drafting is best acquired by learning manual drafting skills[3]. In interviewing various drafting teachers, an overwhelming response was given of the importance of teaching board drafting techniques prior to CAD drafting. The following literature review will examine some of the research conducted on drafting learning strategies in general.

This paper explains the process used to develop a course that was accepted by all state institutions of higher education to be used by all high schools in the state for concurrent enrollment. Understanding the history of drafting education and how the best practices of teaching, collaboration, and online course development have resulted in a Flipped Classroom course using online course management tools. The development team created all of the content in the course including all of the video tutorials.

Understanding Drafting Technology Education

In order to understand the changes in the field of drafting education, one must view a historical sequence of the development of computer aided drafting, from the early manual drafting tools to the use of 3-D solid modeling software. This in turn will provide a comparison of technological advancements, their development in relation to CAD, and their uses and initial high cost which, in turn, made them prohibitive to use in the educational setting[9]. The efforts of the engineering drafting and design technologies are to improve the physical environment. Since those early days these efforts have become more efficient[15].

Drafting has evolved from clay tablets, papyrus, and parchment (some of these date 3000 B.C[2]) to today's mechanical and computer tools. The development of CAD and the creation of course syllabi to prepare students for employment in drafting and in the manufacturing fields is an ongoing quest. Students learning drafting need to apply mathematical concepts, demonstrate fundamental drafting skills, and prepare mechanical production drawings not only by mechanical drafting tools, but also using computer-aided drafting systems[8].

Drafting and computers

With the introduction of computers into drafting education, new needs were created. Some of these needs are: set up of the physical learning environment, new methods for displaying

teaching aides, the development of security measures for the lab equipment, the storage of hardware, procedures for software file management, and installation and up keep of the software. Additionally, choosing the appropriate plotting devices is essential to the CAD Laboratory[12].

Drafting education has evolved into a more technologically demanding field[4]. Teachers and students need to be actively involved in the educational process in order to create an exceptional drafting program. The teachers need to pay close attention to the goals of the particular school, know how to integrate other disciplines into the drafting program, and how to take into consideration the layout of the physical facilities. The teacher needs to assess the software necessary to give the students a solid foundation in the field of drafting[14].

Research shows that students learn better at their own pace, in a setting in which the teacher assumes the role of a facilitator instead of as the disseminator of knowledge[21]. By implementing the use of CAD in the drawing and design process, the man hours required to produce a set of working drawings were dramatically reduced. The archival and retrieval speed increased because of the storage possibilities in the computer system. Prior to the purchase of this new technology, all the drafting was accomplished by manual means[11].

Integration of Manual and CAD Drafting Instruction

In the field of drafting there is an increased need for a systematic approach to the teaching of manual and CAD drafting techniques[5]. The lack of CAD knowledge shown by some experienced draftsmen who are not fully familiar with CAD programs can be seen as a detriment by some people. They argue that the strategies used have a strong likeness to manual drafting techniques, and that manual drafting techniques have no use in a CAD setting. Additionally, some recommend that the specific knowledge of CAD should be made explicit and introduced early in the training sequence of all prospective draftsmen[5].

Should students training as draftsmen be taught basic drafting skills as well as computer-aided drafting, or should they be taught CAD only? This is a question asked at every level of training. One of the arguments is that traditional board drafting reinforces important drafting terms such as parallelism, perpendicularity, and geometric construction. These are terms needed to be successful in the field of drafting. Conversely, CAD automatically constructs parallel lines, perpendicular lines, and is able to construct complex geometry. Most students do not grasp these concepts using only CAD. It is very important to teach basic drafting skills prior or in conjunction to CAD[3].

The importance of preparing hand-drawn sketches to communicate main ideas is evidenced by the need to rapidly communicate ideas to others. Some of the new engineers have a lack of experience in preparing sketches by hand due to their training in using computer aided drafting and digital imagery to communicate information graphically. Rose[19] explains that in education and professional practice, hand-sketching practices are being overlooked. He makes the comparison between practicing engineers from an early generation and the engineers trained today. He states that the early generation of engineers understands the importance of quickly being able to prepare hand-sketches to communicate ideas to their clients. He also points out that current students might not see the benefits of acquiring these skills, and that opportunities to

practice, develop, and obtain hand-sketching skills can be incorporated within the undergraduate curriculum[19].

Teaching Sketching and Visualization

The basic and most important drafting techniques can be taught to students by teaching technical sketching instead of technical drafting, which in turn will develop skills far more valuable than manual drafting[1]. Studies indicate that in engineering and design, one of the most frequently used graphic communication skills is freehand sketching[11]. Another skill that needs to be developed by the students is the visualization skill, yet this important skill is almost completely ignored in most of the drafting or graphic texts[7]. Visualization encompasses at least the relation between two-dimensional representations and real 3-D objects[16] and the capability to relate and form images connecting these two worlds[17]. Everyone involved in the design process agrees that the ability to visualize is a vital skill and a new and effective method of teaching visualization must be found. Keeping in mind the rapid change in technology, some people focus on the conceptual aspect of the engineering and drafting process, and perceive the current CAD tools as drafting instead of design tools[10]. Instructors fear that sustaining Computer Aided Drafting in design education will lead to the loss of hand drawing skills[20].

Benefits of Computer Aided Drafting

The benefits of using computer aided drafting and design are to increase productivity and to provide customers with better, more cost efficient working drawings. The example of using mobile CAD to provide customers with a more accurate estimate can be given. The architectural team is brought to a potential customer's location, bringing with them laptop computers loaded with the CAD software. During the visit, the team creates drawings on the laptops instead of using traditional notepads. At the end of the visit the customer is given a rough drawing containing all the future changes. Then the team goes back to the office to create final drawings and proposals in less time than is traditionally required. CAD software employs the use of layers to increase accuracy and speed. Layers are an important feature of CAD. Before this technology, layers could only be done at a great expense due to the man hours needed to produce them manually[13].

Creating a New Course

The drafting and design world have undergone drastic technological changes. These changes have had a huge effect on technology and engineering education. The course objectives and assessments at the state level has been a subject of discussion for several years as a result of the fast paced changes in technology and how it is reshaping the industry. This presentation will explain how the use of online course content and the flipped classroom model was used to increase the amount of material presented in the classroom and enhanced the learning and understanding of the student with applied skill development.

The technology used to generate mechanical drawings has evolved significantly in the last few years. The use of CAD (Computer Aided Design) software not only provides fast and efficient tools to generate these mechanical drawings but provides tools for design review and evaluation.

The designer of today must understand the design intent and constraint requirements of the part and/or assembly being created. It is critical that these concepts be incorporated into the existing drafting and design course without neglecting the fundamental concepts traditionally taught in this course. Time in the classroom remains constant but the content has increased to include the use of software. Although the technology has evolved significantly, the fundamental principles of drafting and design have not changed. This course was designed to cover the fundamental concepts of drafting and design while incorporating the forward thinking and preplanning of the part and/or assembly required by emergent CAD technologies.

For this purpose the Curriculum Development Team was composed of selected instructors from across the state to create a web-based book (PDF and/or eBook) that teaches the principles of drafting and design at the process level to promote curriculum acceptance and implementation from K-12 to Post-Secondary Education. This will provide a method for every school in the state to use the same book and objectives, and achieve the same outcomes for a concurrent enrollment class accepted by every state college/university. This will provide the link to a higher educational path for high school students wanting to enter a career in an engineering profession early in their education regardless of their geographic location. Given that this book focused on the process level, it can be used without going out of date. The components in each lesson have applied techniques that can be applied to any CAD software and any version (release) of that software. The book will be accessible through Canvas as an online course delivery tool. The entire course was developed around the state objectives for both the pre-engineering and drafting technology programs.

The Need for Curriculum Change

The technology used to teach fundamentals of engineering, drafting and design has changed significantly during the last two decades, creating a disconnecting effect on technology and engineering education. All the Utah System of Higher Education (USHE) institutions and Utah State Office of Education (USOE) Districts use a variety of different software and curriculum to teach the fundamentals of engineering, drafting and design classes. The changes in technology have created some overlap between the Skilled and Technical Sciences Education program and the Technology and Engineering Education program. The course objectives and assessments at the state level have been a subject of discussion for several years particularly because of the fast paced change in technology and how it is reshaping the industry. The course objectives for the Technology I course and the Engineering Design course are very similar and logically allowed the consolidation of the objectives into one course, resulting in one that could be used for both programs. The number of students this course would affect could double or more. It would help strengthen and optimize the existing CAD Technology and Engineering Education programs throughout the state.

All these issues culminated to create several problems for students interested in a career in engineering, design or drafting: What introductory class do they take? What should the name of the class be? What should be taught in that class? These questions have been interpreted and addressed differently by all USHE institutions across the state. The identity crisis of what to call this course and what to teach in it has been brewing for several years. In fact, each university has named the course differently:

- Southern Utah University –CCET 1010- Engineering Technology Graphics
- Weber State University- DET 1060-Fundamentals of Mechanical Drafting Using 3D CAD
- Utah Valley University- EDDT 1000- Basic Drafting
- Utah State Eastern- EDDT 1010- Technical Drafting
- Salt Lake Community College- EGDT 1010- Technical Drafting I
- Snow College – DRFT 1010-Technical Drafting
- Applied Technology Colleges- DRFT 1010 & 1020-Technical Drafting & Basic Computer Aided Drafting

Further complications arose when a student wanted to transfer credit between institutions. In the past, USHE institutions have not granted transfer credit because they were uncertain as to the rigor and content of the other institution's course. These issues needed to be addressed so students could find a clear path beginning at the high school level to enter a post-secondary program of study for a career in the engineering, design or drafting industry. The pathway needed to be free of obstacles regardless of where they chose to continue their education in the state at the college or university level.

The objectives of the project were outlined as follows:

1. Create a standard yet innovative curriculum and assessment for the "Introduction to Engineering and Technical Design" course by sharing existing knowledge and resources while developing new curriculum and applying new methods of delivery.
2. Combine resources and knowledge from the drafting portion of Skilled and Technical Science Education (USOE) with the drafting portion of Technology and Engineering Education (USOE) to enhance the students' career options while strengthening USHE and USOE technology and Engineering programs.
3. Develop the curriculum in such manner that math or engineering credit can be given for this class.
4. Change the course number and title to match for all USHE institutions.
5. Strengthen working relationships and improve overall knowledge and skill across the state.
6. Provide an opportunity to reach out to smaller rural schools.
7. Meet the Essential Learning Outcomes (ELOs) as specified in Regent policy for General Education courses and/or national standards for student performance (when available).
8. Develop a course using faculty representing multiple USHE institutions in association with public education teachers.
9. Design the course in a hybrid format where student independent online learning is meshed with collaborative classroom activities. The online content as well as teaching guidelines for F2F instruction are developed in CANVAS, the USHE learning management system.
10. Incorporate open education resources when available and of high quality. When possible, TICE courses use open textbooks, reducing students' costs.
11. Require at least one common assessment to be given to all students in all sections. Common assessments are designed to be transmitted electronically. Aggregated results

of the common assessment will be published; disaggregated results will be made available to the instructor and institution.

12. Course content is openly licensed under a Creative Commons Attribution 3.0 license. The copyrights to all instructional materials developed under this grant remain the property of the Utah System of Higher Education. Any USHE institution, regardless of an institution's participation in the development process, may choose to use the TICE curriculum for either concurrent enrollment or regular college instruction.

Course Development Team

In order to ensure the project's success, it was vital to assemble a multi-disciplinary and diverse team that could represent the shareholders of the course. The state identified this course as one of the highest enrolled courses being offered as concurrent enrollment at the high school level. The directive of the state as to the development of teams read as follows; "All Utah System of Higher Education (USHE) colleges and universities faculty are eligible to submit proposals. The greater the number of USHE institutions represented on the team combined with the number of Utah State Office of Education (USOE) K-12 districts represented, the more favorable the proposal."

A team was assembled with representation from all USHE universities and colleges in the state that were granting concurrent enrollment (CE) credit. This included 4 universities, 2 colleges and the state drafting chair for all Utah College of Applied Technology (UCAT) campuses. We also include 3 high school teachers from different geographic locations throughout the state. These institutions were geographically spread throughout the state and provided the general consensus that would be required to develop such a course. The representatives from each institution were acting as CE coordinators for their departments as well as teaching the course that was to be developed and could be content experts in the development of the curriculum. This ensured comprehensive support which included commitments of support for course development and implementation from multiple USHE institutions and USOE districts required by the grant proposal. We included highly qualified high school teachers who were teaching both courses from all corners of the state to get their perspective and buy in to what we developed. We had overwhelming support of the proposal across the state from high school teachers who had been asking for this alignment to administrators at the university and college levels.

Brief description of team members:

Richard Cozzens, professional in residence and CE director for the Department of Technology and Construction Management in the College of Science and Engineering at Southern Utah University. His scholarly work includes CAD conference and book publications, designing software tutorials that apply engineering graphics knowledge. Richard has been involved in distance learning outreach to rural schools that lack the technical expertise to facilitate engineering courses. In addition, he is also working on his doctorate degree studying the effects of teaching using online delivery methods in engineering, design and drafting education.

Jeremy Farner, Professor and CE director for the Design Engineering Technology department in the College of Applied Science and Technology at Weber State University (WSU). He provided the curriculum framework that was developed at WSU to teach an introductory

engineering, design and drafting course at the college level to Design Engineering Technology, Manufacturing Engineering Technology and Mechanical Engineering Technology students. He is an expert in the use of the Canvas Learning Management system selected to house the course.

Elias Perez, an associate professor at Utah State University Eastern (Land Grant School) in the eastern part of the state. He is the CE coordinator for the Engineering Drafting and Design Technology department.

Rex Thornock, a drafting instructor at Ogden/Weber Applied Technology College in the northern part of the state. He is the state chair of the drafting instructors found within the UCAT system.

Dr. Thomas Paskett, high school teacher at Fremont and Bonneville high schools in the northern part of the state. He was previously an associate professor at UVU and is an expert at curriculum development at the high school level. He currently has the highest enrollments in the state for his concurrent enrollment classes in engineering and architecture.

Gary Roberts, high school teacher at Wasatch high school in the central eastern part of the state. He is an expert in online website curriculum delivery and video tutorial creation.

Tim Benson, high school teacher at Canyon View high school in the south western part of the state.

Dr. Shalini Kesar, assistant professor at Southern Utah University. She is an expert in pedagogy & assessment methods. She was brought on the team as an outside source to provide feedback to the group as she is not a content expert in the field. She will be responsible to review the content to make sure there are not gaps or inconsistent teaching methods.

Isabella Borisova, an instructor at Southern Utah University. She has resident expert with the software packages used in the development of this web-based course which include; MS Word, PDF Writer, Camtasia, Snag It, Adobe Connect and Canvas. She trained the team members on advanced software applications needed to develop the course curriculum and training videos.

Each USHE institution had a different course number and title for this course. Now that a consensus based course has been developed, an articulation agreement between each institution to accept the course will be formulated. The development team renamed the course and title so it is the same across all USHE institutions and all high schools. It no longer matters where the course is taken since the curriculum and assessment tools are the same whether it is taken at the high school level concurrently or at a college or university. The remaining challenge will be making the title and number change with the various curriculum committees for each appropriate USHE institution.

Team Results

The goal was to come to a consensus as a state to create a standard yet innovative curriculum and assessment for the "Introduction to Engineering and Technical Design" course. This was done by sharing existing knowledge and resources from the university, college and high school levels and develops new curriculum methods of delivery. This course can be delivered with the traditional face to face method, hybrid method or online delivery method which will facilitate the opportunity to reach out to smaller rural schools. This effort strengthened working relationships between USHE, USOE and ATC's. It also improved overall knowledge and skill across the state in the areas of engineering, design and drafting education. The course joined resources and knowledge from the drafting portion of Skilled and Technical Science Education (USOE) with the drafting portion of Technology and Engineering Education (USOE) to enhance the students' career options while strengthening USHE and USOE technology and Engineering programs. By combining engineering and design objectives, the curriculum was developed in such manner that math credit can be given for this class. This could not have been possible without getting broad support and input to enable a state consensus to be made on what to teach, what to call it and how to teach it.

It was determined that a Flipped Classroom model would be used in the development of this course. The Flipped Model provided the process for addressing the concerns mentioned earlier of integrating manual and CAD drafting techniques in one course. This integration needed to be accomplished in a manner that satisfied the course objectives of each institution of higher education throughout the state of Utah. This course will be in pilot mode for the 2013-2014 school year in high schools and colleges throughout the state. The Flipped Classroom places more responsibility on the student to review material and attend the live class prepared to work and ask specific questions.

The Flipped Classroom Advantage

The advantage of incorporating an online component such as a blog, an online course management system or a course website is that it allows for a wider range of content that the students can be exposed to outside of the classroom. The advantage for an instructor is that students can access reading content, review podcasts of techniques, and work on projects at their pace and level. The advantage for student is that they can review lecture videos and PowerPoint files, complete preliminary project inquiry and research, and complete homework assignments.

In each module of the course, written content was provided to allow students to read and review key concepts of the topic. For example, a student could read on how to use a CAD command or review what line type should be used to create a section view. For the more visual learner, a video is also provided for the student to review. Each video created by the team included the function of being able to rewind or pause the playback.

The online aspect of this course allows for students to learn how to use the software available in their high schools form the provided video tutorials. The tutorials for this course have been developed by the curriculum team and provide step-by-step guides using both 2D and 3D

software packages. To maximize the potential of the course, each module was developed to appeal to the student and maximize the learning potential.

Course Structure

The course was developed using the Canvas Online Learning Management system. Each module was developed and planned following the best practices of online course management with the end user learner in mind. As mentioned prior in this paper, there is currently a conflict between the traditional methods of teaching drafting and the current need to teach CAD applications. Today's students are digital natives and prefer the use of CAD software to board drafting techniques.

The course is composed of twelve learning modules composed of text, video, quizzes, worksheets, drawing assignments and team projects:

Module 1 – Introduction to the Engineering Design Professions
Module 2 – Documentation and Sketching
Module 3 – Design Measuring and Data Collection
Module 4 – Geometric Construction and Introduction to CAD Drawings
Module 5 – Design Visualization (2D and 3D Orthographic, Oblique and Perspective)
Module 6 – Multi-view Drawing
Module 7 – Fasteners
Module 8 – Assembly Drawings
Module 9 – Dimensioning
Module 10 – Geometric Dimensioning and Tolerance
Module 11 – Project (Engineering Portfolio)
Module 12 – Additional References and Materials

Marc Prensky[18] coined the term "digital natives" in his article *Digital Natives, Digital Immigrants*. His premise was that "Today's students are no longer the people our educational system was designed to teach" (p. 1). He argued that today's students represent the first generation to grow up with new technology. However, the reality we would like to propose is that today's students are not too different from the students who grew up with the Iron Horse, the addition of the telephone to every home, the electric light, the 8-track tape player, or even the automobile. Each time technology advances, education adapts to meet the needs of the student.

Digital natives are defined as students who "have spent their entire lives surrounded by and using computers, videogames, digital music, … cell phones, and all the other … tools of the digital age"[21]. These students have never used a rotary phone or cassette recorder. Their games have always been electronic: Wii, PlayStation, or Xbox. Most have never thought of life without a cell phone. Even their music is digital; they purchase one song at a time from iTunes. Written communication is in the form of texting and, to a lesser extent, email. Utilizing the affinity of the digital native towards online leaning and the benefits of the "flipped classroom" model, the development of this course merged both philosophies.

The concept of a flipping a classroom began in 2004 by Jonathan Bergman and Aaron Sams. Both were teaching at Woodland Park High School in Woodland Park, Colorado. The two began

developing lesson plans together since they had similar teaching styles and philosophies. What they noticed is that many of their students were missing a lot of class time as a result of extra-curricular activities. As a result, their students were struggling to stay caught-up.

Upon discovering that software was available to record a PowerPoint and include a voice over explanation, the proverbial light bulb lit up. In the spring of 2007, they began to record their live lessons and post those lessons so that their students could access them to review and stay current the lesson topics. From this, the application of a Flipped Classroom was developed.

Rather than using teacher-to-student face time in class to lecture, students review lecture podcasts before class and then apply and discuss those concepts with the facilitation of the instructor. The result was that Bergman and Sams began to see that their students were helping each other learn instead of relying on their instructors for subject content.

Initial efforts using technology to extend the class room experience of the students to their homes began with email. Students were encouraged to email homework questions and include a screen capture when they could not find a solution or answer themselves. The availability of personal blogs allowed for lecture content such as worksheets, PowerPoint files, and articles to be loaded for the students to access. The availability of online course tools has made it easier to provide content in an organized fashion.

Prior to using online course content parents would comment, “What is it that you teach” and “What is my child actually doing in your class” now comments are, “I cannot get him off the computer, I thought he was playing games, but he was doing homework.”

“Digital pioneers” are those who choose to employ the concept of a flipped classroom. Every day we learn new ways to connect with students, and meet the multiple intelligences that are in our courses. We are fortunate that current technologies allow so many ways to best deliver the content of our courses. When using the various technologies available, there are some transferable techniques from online courses that are helpful with the flipped classroom development.

The modules for this course followed J. V. Boettcher’s[6] (2011) the *Ten Best Practices for Teaching Online*. Below is a summary of each practice and how they were adapted to develop this course. Four foundational philosophies (Prepare, Teach One Another, Ponder and Prove) were used to create the course and each module of instruction.

Best Practice 1: Be Present at the Course Site[6]

Each module of the course includes a lesson reflection where students can post an evaluation of the lesson. A question and answer discussion board is also an important aspect of the course where students can ask each other questions as well as receive responses to questions from their instructor. Further contact with instructors can be made with email.

Students expect that their instructors will be present in an online course multiple times a week, and at best, daily. A flipped classroom instructor should develop three types of presence: social

presence, teaching presence, and cognitive/content presence. In most electronic courses, the dialogue of faculty to the student is provided through 1) mini-lectures in text or in video or audio podcasts, 2) weekly coaching and reminder announcements, and 3) explanations or interactions with the students. Instructors should establish clear expectations as to when they will be present or not at the beginning of a course. "Being present" in a course can be accomplished in a variety of ways: commenting on discussion posts, sending announcements, replying to email, or calling the disengaged student.

Students who feel abandoned or alone may post questions or comments, such as, "Is anybody there?" or "I am not sure if this is where I am supposed to post this…" When instructors see these, they need to react and reaffirm class expectations of participation. However, experience has taught that expectations may not be enough to motivate every student. It is important for instructors to maintain an active presence by engaging in course activities and assessing student participation. For example, discussion posts that are not read and graded by the instructor are less likely to have participants.

Best Practice 2: Create a Supportive Online Course Community[6]

A major component of this course is the team project. Students need to learn to work together and in this course teams are established to solve a design problem. The team must document their progress in terms of success and failure as well as how they are working together. The concept here is that the students not only support each other, but teach one another as they push their own individual understanding of techniques and software application.

It is important to launch each course with personal introduction postings so that students can get to know one another, their goals and fears, and past experience with the subject matter. Instructors should also include a profile about their experiences and interests.

Instructors are encouraged to use open-student forums for students to post and request help and assistance from each other through various student-to-student tools such as discussions, help areas, Adobe Connect, Skype, etc. Discussion boards or course newsletters can be used to celebrate school athletic victories, student achievement and other times to cheer collectively as a class. The instructor of a flipped classroom needs to respond to student questions by communicating clearly and respectfully with them. Community building is further enhanced when instructors actively participate in student discussions and regularly reach out to those who need additional support, guidance, and encouragement.

Instructors should also develop group activities that foster an online community and allow students to engage their peers. Setting up small groups of three to five students early in the semester allows them to assume responsibility for supportive mentoring and for summarizing key points of a class assignment—they teach one another.

Best Practice 3: Share a Set of Clear Expectations for Your Students and for Yourself[6]

The written text along with video explanation of course standards of quality are essential to the student's ability to achieve the desired outcome. The course contains detailed examples and step-by-step demonstrations to assist the student. Each assignment and project instruction contains a grading rubric so that the students understand the expectations that will determine their grade.

Expectations should be clearly established, stating, for instance, how you will communicate with students, how much time they should be working on the course each week, how each project will be grade based in a provided rubric, what a proper discussion thread should look like and the etiquette that is expected. Include in each lesson a schedule at the beginning of each week, letting students know what to expect throughout the week and encouraging them to plan accordingly.

Best Practice 4: Use a Variety of Large Group, Small Group, and Individual Work Experiences[6]

In each module is a mixture of individual assignments and drawings. Some of the individual drawings will be combined with the work of other students for their group project. Being able to produce a drawing that can be combined with the work of another student creates a workplace model for the student.

Working in teams is particularly effective when working on complex case studies or scenarios for the first time. Students will resist being organized into groups. Many have the idea that any online content is an independent study. Online content should have rigor and solid content. Instructors who utilize student groups can expect to receive student feedback like this:

> One thing that has stuck out for me this week was the opportunity to spend time and talk about the assignments to my fellow group members. Especially regarding one question within the homework assignment, the majority of the group had the same answer while one had a different answer. Usually when things go down, majority rules, however, when that individual spoke out and was very adamant about his conclusion, which made sense, we "swallowed our pride" and figured out that he was correct and made perfect sense. Without having groups to talk about what we think we know and work it out, we would have all been wrong and stayed wrong until someone would have told us different. It's a great blessing to have this chance to work in groups and get to know one another. (Jon N., 2011)

Best Practice 5: Use both Synchronous and Asynchronous Activities[6]

Through the use of the Flipped Classroom Model, students engaged in asynchronous activity prior to class. These activities are reading assignments, quizzes, homework exercises, and in some cases, drawings. Synchronous activities occur in class. The traditional class period becomes a working lab where students can ask questions, resolve concerns, and work on team projects. The instructor is free from conducting traditional lectures and can spend more time working with individual students. Students are able to get more of the instructor's time. This is

especially good for students who may be under the radar and not as likely to get the support they need in a traditional class. Being able to contact the instructor through email and discussion boards while out of the classroom generates increased levels of trust and support.

The value of an instructor connecting with the students in real time is just as important as that of the instructor in a live course. However, there are times when students need to reach conclusions on their own. The variety of activities that are now available electronically makes it possible to create many types of effective learning environments. There are course management systems, virtual live classrooms, and audio tools that make it possible to do almost everything that is done in a classroom. Students can submit presentations, conduct research, and even present project-based learning assignments such as drafting, sculptures, and auto repair.

Best Practice 6: Informal Course Feedback[6]

Each module in the course has a reflection discussion board where students can post their personal review of what worked well in the module, and in what areas or topics they need additional instruction. The value of these lesson reflections is the immediate formative evaluation that they provide for the instructor. In this way the instructor is able to provide additional instruction or resources during the live class session. These reflections also provide the data needed to improve the course to best meet the needs of the instructor and the student.

Early in the course (about week 3), instructors should seek informal feedback from the students on how the course is going, and ask if they have suggestions for improvement. Knowing what the students are experiencing early in the course allows for instructors to make adjustments, clarifications, and offer additional support. This is a formative evaluation for the course—the data collected are for the use of the instructor to improve the course and should not be required or graded.

Best Practice 7: Prepare Discussion Posts that Invite Questions, Discussions, Reflections and Responses[6]

Instructors using this course can add discussion boards in addition to those that are built into the course. Discussion boards can be a way to conduct exam reviews, create areas where class teams can discuss their project, and where the class as a whole can ask questions of each other and the instructor. The discussion boards are a tool that instructors can use to personalize the course to be their class. Every instructor who will be using this course will be trained during a Summer Conference. This will announce the launch of the course to the pilot stage.

When using discussion boards, a few simple procedures help to keep the students engaged:

- Provide an open question and answer forum. Open-ended questions encourage the learner to explore and research the subject and concepts being studied. Provide the student with the choice to respond to one or two discussion thread options.
- Encourage critical or creative thinking. Stagger the dues dates for posts and responses. This will allow more time for reflection and fewer comments that restate the responses of others. Consider requiring a mid-point summary. When replying to student postings,

instructors should model good Socratic-type probing and follow-up questions, such as, "Why do you think that?" and "What is your reasoning?" Do not post questions soliciting basic facts, or questions for which there is an obvious yes/no response.

- Reinforce domain or procedural processes. Let the students know that responses like "I agree" and "Ditto" are not complete. Require two-part responses to posted questions. Ask clarifying questions such as, "Why do you agree?" or "What questions are left unanswered?" to encourage students to think about what they know or don't know. Offer two or more questions for the students to answer. This gives them a choice in the direction of their own learning inquiry.
- Achieve social interaction and community building – have the students get to know each other personally and intellectually. Provide guidelines and instructions on how students can and should respond to others.
- Validating experiences can build a student's confidence. While we think that today's students are all tech savvy, the reality is that many are just as unsure today as they were twenty years ago. All students share one thing in common: They need to know that they matter and that their opinions have value.
- Support students in their own reflections and inquiries. .
- Remember to log in to your course at least 5 times a week–answer email, monitor discussions, post reminders, and hold online office hours.

Best Practice 8: Focus on Content Resources, Applications, Links to Current Events, and Examples that are Easily Accessed from the Learners' Computers[6]

Each module in this course contains an area where additional resources and content can be found for the instructor who desires to provide more detail on a topic. This folder also contains resources for the students to use in the design process, such as size tables and charts, CAD standards, drawing standards, etc. The design team did their best to anticipate the needs of those using the course. Each instructor can also submit additional materials to be included in the module. These materials would be files they use in their current teaching methodology. These resources are then available to the entire state.

With the increased cost of textbooks, today's students are more likely to seek information on the internet than to purchase or read a book. While publishers continue to provide more eBooks, the savings may not meet the students' need. Podcasts, web links, YouTube content, and industry web pages offer current and accurate information that can be accessed in any time zone and in any country. Try letting the students help discover current course content and verify that links are active.

Best Practice 9: Combine Core Concept Learning with Customized and Personalized Learning[6]

This core concepts and personalization of projects are addressed in the course. The Common Core for K12 education of writing and mathematics are part of the capstone engineering project. The students write essays and preform engineering calculations as a part of the design process for this course. These written assignments can be customized by the instructor. In reference to

the design project capstone of the course, multiple projects are provided for the instructors to choose from, or they can develop their own and use the provided rubric and portfolio outline.

Instructors of a flipped classroom provide the core concepts to be learned in each lesson or module, as well as the performance goals and the assessment tools for the course. The instructor then mentors learners through a set of increasingly complex and even customized projects applying these core concepts. Assignments and projects should result in the student feeling that the learning is more personal. Online assignments should require students "…to create, talk, write, explain, analyze, judge, report, and inquire"[6]. A student's self-awareness of knowledge acquisition increases when learning activities incorporate these skills.

Best Practice 10: Plan a Good Closing and Wrap Activity for Each Lesson and for the Course[6]

The closing activity for this course requires that the students be organized into teams. Each team is to develop prototype models and rapid prototypes, where possible, of an assembly. Each assembly has a minimum number of parts. The team needs to complete all of the working drawings for manufacturing including assembly drawings and bill of materials. Each team also completes a design portfolio composed of sketches, calculations, and story boards.

Students seem to be in a heightened state of stress towards the end of a weekly lesson. Take time to remind the students what they have learned. This can be done with digital games, discussion boards, or weekly reflection posts. Instructors should post announcements and/or emails that explain what to expect the next week.

When ending the course, individual and/or group presentations are a great way for course summaries to be delivered. Course wikis that allow students to write a letter of what to expect to the next class is another way that students can reflect on what they experienced and learned. This is a time to celebrate the successful completion of the course.

Utilizing these practices will result in the following benefits:

- More time to spend with individual students during classroom time, rather than lecturing.
- Students have full access to course content when they need it.
- Data to reflect upon, that allows for further course development.
- The learning is individual for each student and their own learning style.
- Students know what is being taught one which day and when it is due, even when they miss a class.
- The flipped class has allowed for content to be more deeply explored.
- Students have learned to work collaboratively.
- Students learn the theory at home and apply the concepts and skills in the class.
- Skills test scores have increased.

It is important to recognize that not every student will have the access to a computer or smart phone in which to access course content. Burning individual DVD's in not an effective use of

money or time. The reality is that some students will need to use class time to access the course content. The content is the text.

This course will be in pilot for the 2013-2014 school year. Each instructor who will be teaching this course will be trained in how to use the online course materials and manage the course content in a Summer Conference in June of 2013. The design team expects the course to be continually improved as instructors submit suggestions and add additional materials. Provisions are being made that would allow the proceeds from the sale of the text and video tutorials to be used for a perpetual course improvement fund. In this way, the course can be maintained without additional funding from the state.

Conclusion

The most important aspect of developing an online course is to keep the needs of the students as the priority. It is not about how much content can be loaded into the course, but rather the amount of learning engagement that takes place. Development teams should ask, "How will the student interpret this?" "How long will it take to complete?" "What is the desired outcome?" and "What is the best tool to use for delivery?" As technology continues to advance, more tools become available to deliver course material. A guiding rule-of-thumb should be, "Just because I can use this tool, should I?" As instructors sincerely strive to follow best practices for teaching a flipped classroom, they will be well-equipped to make good decisions that will enable them to reach all of our digital learners—including the digital natives.

From the research cited it can be understood that that drafting is an evolving subject and skill. Learners need to understand the basics of drafting along with CAD drafting principles. The research shows a great need for more studies to be conducted on the subject due to the relative newness of the introduction of computers in the drafting field. Students will be the beneficiaries of such research. The literature cited also implies that students who receive a well-rounded drafting instruction, including, technical drafting and computer aided drafting techniques will be able to perform better in the field than the students that only received computer aided drafting instruction.

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