

ABSTRACT

MAPSON, KATHLEEN HARRELL. Best Practices for Designing Online Learning Environments for 3D Modeling Curricula: A Delphi Study. (Under the direction of Dr. Aaron C. Clark and Dr. Jeremy V. Ernst).

The purpose of this study was to develop an inventory of best practices for designing online learning environments for 3D modeling curricula. Due to the instructional complexity of three-dimensional modeling, few have sought to develop this type of course for online teaching and learning. Considering this, the study aimed to collectively aggregate information on the type and appropriate use of various instructional technologies, instructional/course design, and drawing and modeling content. Each of these areas directly impact student response and retention in online environments.

The questions guiding this research study were (1) What are the key components necessary for designing a quality introductory modeling course for online environments? and (2) What technologies are essential for the instructional design of the modeling course and implementation of the course design? In order to answer the research questions, a three round web-based Delphi methodology was elected. After progressing through this iterative approach for collecting and organizing information, the final inventory of best practices was determined. A twenty-nine member panel chosen from the Engineering Design Graphics Division of the American Society of Engineering Education and the American Design Drafting (Digital) Association, reached consensus on the components presented in the study as well as those derived from the panel.

The results of this study yielded forty components from the categories Learner-Centeredness, Course Design (which included instructional and interactive technologies), and

Drawing and Modeling Content. The components from these categories were to be considered or included in the development of introductory 3D modeling courses or comparable engineering graphics courses. The results also indicated that although there was low agreement on the use of collaborative tools, methods for acquiring course information was multi-dimensional. These methods included: utilizing a Learning Management System, using application sharing tools for live demonstrations and assessing student knowledge, providing interactive exercises that react to student input, exchanging ideas via discussion boards, delivering content using lecture capture videos, recording demonstration videos for sketching practices, creating screencasts to present step-by-step processes, and incorporating simulations and /or animations in instruction. Based on the results from this study, the inventory of best practices would serve as an instructional blueprint for post-secondary educators seeking to develop a quality 3D modeling or comparable engineering graphics course taught as a hybrid or fully online course.

Best Practices For Designing Online Learning Environments For
3D Modeling Curricula: A Delphi Study

by
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DEDICATION

I dedicate this to my husband Otis for all of his love, encouragement, and words of wisdom. You have sacrificed and provided so much for our family in order for me to accomplish this. I thank God for blessing me with someone as wonderful, devoted, and loving as you, and I couldn't imagine life without you by my side. I love you forever.

To my beautiful children, Judah and Neema - thank you for your love, hugs, smiles, and laughter - always lifting my spirit when I needed it most. My heart is so overwhelmed by the purity of your love. You are both precious gifts given to me by God and I am so grateful he entrusted you both to me. I feel immensely blessed to be called mommy by you both and I love you more than life itself.

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BIOGRAPHY

Kathleen Denise Harrell Mapson was born in Ahoskie, North Carolina to James and Charleen Harrell, and spent her childhood playing with her big sister and many cousins on the grounds of her grandfather's 188-acre farm. Early on she recognized her passion for technology and design, and pursued an undergraduate degree in Graphic Communications from North Carolina A&T State University and a Master's degree in Technology concentrating on Computer Graphics and Instructional Design from Purdue University.

Over the last decade, Kathleen has worked in industry, public education, and higher education as an instructional designer and as a teacher in multiple areas of design. Her academic areas of interests include how to effectively identify, integrate, and manage the use of instructional technology to enhance teaching and improve learning outcomes, and utilizing graphic and information design to effectively communicate and deliver course material.

Outside of her academic activities, Kathleen enjoys painting children's art, abstract art, and working on interior design projects. Kathleen lives with her husband Otis, and their two beautiful children Judah and Neema in Marietta, Georgia.

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My academic journey dates back to my freshmen year at North Carolina A&T State University where I met three wonderful professors along the way, Dr. David Dillon, Dr. Arjun Kapur, and Dr. Marcus Tillery. Their guidance during those years was monumental toward all my successes and the stepping-stones for this great accomplishment. Many thanks for their support, encouragement, and words of wisdom throughout the years.

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CHAPTER 1: INTRODUCTION

The presence of technology in society has forced a dramatic change in the teaching methods of engineering graphics educators in higher education. As these technologies continue to evolve and materialize into a system that was previously unimaginable, engineering graphics educators should strive to deliver instruction in a manner that is relevant and accessible to today's learners (Branoff, Hartman, & Wiebe, 2001). Engineering graphics educators must not only consider the traditional class settings and methods of instructional delivery, but must also explore nontraditional education environments such as online learning.

Primarily driven by social change (Rogers, 2000), online learning is altering the landscape of the college educational experience. Today's learners are interested in flexible learning systems that can present instruction based on individual learner needs (Beldarrain, 2006) and convenient accessibility. The Internet has increased learners' abilities to acquire education without the boundaries of time and place (Beldarrain, 2006; Benson et al., 2005) and is reshaping how information is conveyed (Zang et al., 2004). Twenty-first century learners are therefore, reevaluating their place in the traditional face-to-face learning environment and enrolling in online courses.

In the 2006-2007 academic year, the National Center for Educational Statistics (2008) estimated that at two-year and four-year institutions a total of more than 12.2 million students were enrolled in distance education courses, which included credit and noncredit online and hybrid/blended courses. Of the 12.2 million enrollments 65% were listed as college level credit granting courses. Acknowledging that online learning has the capability to address the

long-established barriers of individual and university scheduling and location conflicts (Flowers, 2001), many institutions have recognized the value of online learning (Royer, 2007) and have begun to offer individual courses and degree programs online (Smith & Winking-Diaz, 2004). Although postsecondary institutions have begun developing specific programs for online instruction, degree programs such as engineering graphics education, are slow to progress towards the full potential of the theory and practice of online learning (Totten & Branoff, 2005).

STATEMENT OF THE PROBLEM

Engineering graphics educators are faced with a dilemma when developing 3D modeling courses for online instruction. Because a vast array of instructional methodologies and technological tools exist many engineering graphics educators are uncertain about which of these is most appropriate for selection and utilization in course design. Given this, the presence of online instruction for 3D modeling courses is hardly present. Therefore a need existed to identify the best practices that are associated with designing a quality, 3D modeling course for online environments. This inventory will serve as a guide to assist engineering graphics educators in post-secondary education with the development of online modeling courses.

Online teaching and learning is becoming increasingly popular and while obtaining a greater presence and becoming one of the most important factors in acquiring a degree in many academic study areas, the instructional presentation or delivery from classroom to computer in engineering graphics education is slow to progress (Bourne, Harris, & Mayadas, 2005). As higher education becomes more competitive, the growth of the student consumer

market continues to rise. New and innovative approaches to using technology, including the use of various hardware and software, has shifted the paradigm and introduced non-traditional methods teaching and learning (Bertoline & Wiebe, 2005). Considering this, a revising of current instructional methodologies and mechanisms may be needed to meet the demand for delivering instruction to an ever changing community of learners. As these technologies continue to progress and create opportunities for multifaceted instruction, engineering graphics educators may have to consider alternative methods of instructional design and delivery mechanisms beyond the traditional classroom setting in order to satisfy the need of the contemporary adult learner.

PURPOSE OF THE STUDY

The purpose of this research is to identify the best practices for developing modeling courses for online environments. This inventory of best practices may be utilized to assist graphics educators in the development and implementation of introductory modeling courses for online environments in post-secondary engineering graphics programs. Utilizing an existing model for e-learning (Anderson, 2008), developed by a widely published distance education researcher, Terry Anderson of Athabasca University, key elements of instructional design, drawing and modeling topics, interactive technology requirements, and adult learner characteristics will be examined in order to identify these best practices.

Because engineering graphics education including 3D modeling is complex and heavily visual, many engineering graphics educators elect to not confront the task of designing this type of course for online learning. The most challenging issues are those that relate to the technological tools needed to address instructional problems while adhering to

instructional design principles for online learning and theories of adult learning (Connolly & Maicher, 2003). Although there is a plethora of information about designing for online learning, there is limited information specific to the field of engineering graphics education and more specifically 3D modeling. In this collection of limited information, a guideline outlining the best practices for developing a modeling course for post-secondary graphics educators is nonexistent.

SIGNIFICANCE OF THE STUDY

The emergence of online learning has changed the landscape of post-secondary education and has extended educational opportunities to a broader community of learners moving beyond the traditional classroom setting (Ernst, 2008). This community of learners is comprised of the traditional student as well as nontraditional adult learners, which include those that are older, fully employed, or have families (Ndahi et al., 2007). Within this group of learners are vast experiences, social, economic and cultural differences. Given this extensive community, the challenge lies in the attempt to address the needs of the learner and to develop an instructional approach that will address such needs (Felder, 2005).

Scales, Petlick, and Clark (2005) noted that for engineering and or technical graphics, the greatest improvement towards course teaching and course listings is the development of online instruction and tutorials. Turoff, Smith, and Ferguson (2002) mentioned that the online delivery of instruction could provide to be a useful educational tool. Considering this, if graphics education is to progress with this new educational paradigm, the modification or reinvention of instructional delivery in graphics education is paramount. Totten and Branoff (2005) suggested that when developing online courses for engineering graphics, graphics

educators are specifically faced with challenges such as determining appropriate and effective methods to demonstrate software, developing instructional materials that are primarily comprised of graphic imagery, and ascertaining the most accurate and adequate processes for assessing student work; all of which must be resolved in order to develop a quality online modeling course.

Developing a quality 3D modeling course for online instruction is laden with challenges. Other points to consider include whether or not the course design is pedagogically sound, the course is supportive of increasing enrollments, and the course maintains the highest level of educational quality. In order to identify the best practices for the development and implementation of an online 3D modeling course, factors that address the challenges and contribute to the overall quality of an online modeling course should be identified.

RESEARCH QUESTIONS

To identify the inventory of best practices for the development of modeling courses for online environments, key elements of instructional design processes, modeling and design concepts, and required technologies were considered. The research questions guiding this study included:

1. What are the key components necessary for designing a quality introductory modeling course for online environments?
2. What technologies are essential for the instructional design of the 3D modeling course and implementation of the course design?

ASSUMPTIONS

The following assumptions were considered throughout the process and procedures used within the study:

1. There was a need to establish an inventory of best practices for the development of modeling courses for online environments.
2. Panel experts participating in this study were knowledgeable in instructional design for modeling courses, teaching and learning in the online environment, distance education, and/or technology requirements for the implementation of online courses.
3. Panel experts responding to the data collecting instruments understood all instructions.
4. All information gathered was accurate, current, and related to designing introductory modeling courses for online environments.
5. Key elements of course design were validated through the conventional Delphi process using a panel of experts in the field of engineering graphics education with online education experience to provide insight pertaining to designing and implementing courses for online environments.
6. Panel experts had Internet and email access for receiving participant correspondence or notifications.

LIMITATIONS

The following limitations were considered for this study:

1. The results of this study were based on the data collected by the instruments derived by the researcher of this study.

2. The results of this study reflected data collected from the panel of experts. Quality of the data may vary depending on time and priority made available by each participant.
3. The Delphi study responses reflected the opinions of the expert panel. Therefore, existing biases of online learning for graphics education possibly existed.
4. The Internet was used to collect information for consensus. Participation was limited to those that have email and Internet access.
5. Due to time constraints, distance, and cost, four data-collecting instruments and three follow-up mailings were used to gather information for the Delphi process.

RESEARCH METHODOLOGY

Due to limited existing research for online course development specific to the field of engineering graphics education, it was essential to identify the key components for the development of modeling courses as well as technology requirements for course implementation. Therefore, this study examined online instruction and its applicability to introductory modeling course development. The primary audience for this study was engineering graphics educators in post-secondary education, developing and/or teaching introductory modeling courses in online environments.

A web-based Delphi was utilized to obtain expert knowledge from individuals working in online course development for engineering graphics education. The Delphi consisted of three rounds, which were used to achieve consensus from the expert panel (Linstone & Turoff, 2002) on the inventory of best practices for online course development. This technique identified the best practices for modeling courses, including online learning instructional criteria and technology requirements. The data from the Delphi study was

collected through a dedicated web site for the research study. This web-based Delphi process was used to compile the information collected from the panel experts (Colton & Hatcher, 2004). Web-based instruments were created using Survey Monkey for each round of questioning. Upon completion of the Delphi process, an inventory of best practices for engineering graphics educators in post-secondary education was identified.

Panel Selection

The Delphi process began with soliciting participants for the expert panel and the review panel from the Engineering Design Graphics Division (EDGD, 2010) of the American Society of Engineering Education. This organization was selected based on its overall mission and presence within its respected area. The overall purpose of the Engineering Design Graphics Division of the American Society of Engineering Education is to serve as a learning network that provides professional dialogues of ideas including current and future trends in engineering graphics. It also provides direction and support for instruction and application of software, and serves as a connection to other professional organizations, as well as industry and government (Engineering Design Graphics Division, 2009). In order to attain a higher number of participants, the American Design Drafting (Digital) Association (ADDA, 2010) was also contacted. This organization shares a similar mission as EDGD, which includes the advancement of the drafting profession, the support and continued usage towards the improvement of technology, serve as a professional learning network for educators and professionals, to cultivate the spirit of camaraderie amongst members (American Design Drafting (Digital) Association, 2011).

After reviewing the notification about the study, interested potential panelist selected the Demographics Questionnaire to submit their information. Based on the criteria for participation set forth for this study, panelists were selected. The criteria included professional affiliations, education, and experience with developing and/or teaching modeling curricula for online environments. From this selection of individuals, 32 participants were selected for participation in this study. A review panel consisting of a total of three individuals was randomly selected utilizing a random number generator from the total (32) number of qualifying participants (Delbacq, Van de Van, & Gustafson, 1975). The review panel assessed all questionnaires and modifications made by the researcher in order to eradicate researcher biases during the revision phases. Assessment of the questionnaires was also to help ensure the clarity of the instruments. Expert and review panel members remained anonymous to one another throughout the study in order to avoid influence or authority over another.

Delphi Study Instruments

Round 1

The instrument for Round One of the Delphi process was developed from information found in the review of literature, Chapter 2. Categories and open-ended questions containing information about key elements of instructional design, drawing and modeling principles, and interactive technology requirements were established and listed in each questionnaire. Upon approval of the questionnaire by the review panel, the questionnaire was made accessible to the panel of experts via email. One week after the initial contact for the Round One questionnaire, the panel of experts received a reminder via email, to complete and return

their responses. Throughout each round, expert panel members were given the opportunity to revise or provide input about the results in a separate text field. The researcher tabulated results from Round One with like components collapsed together.

Round 2

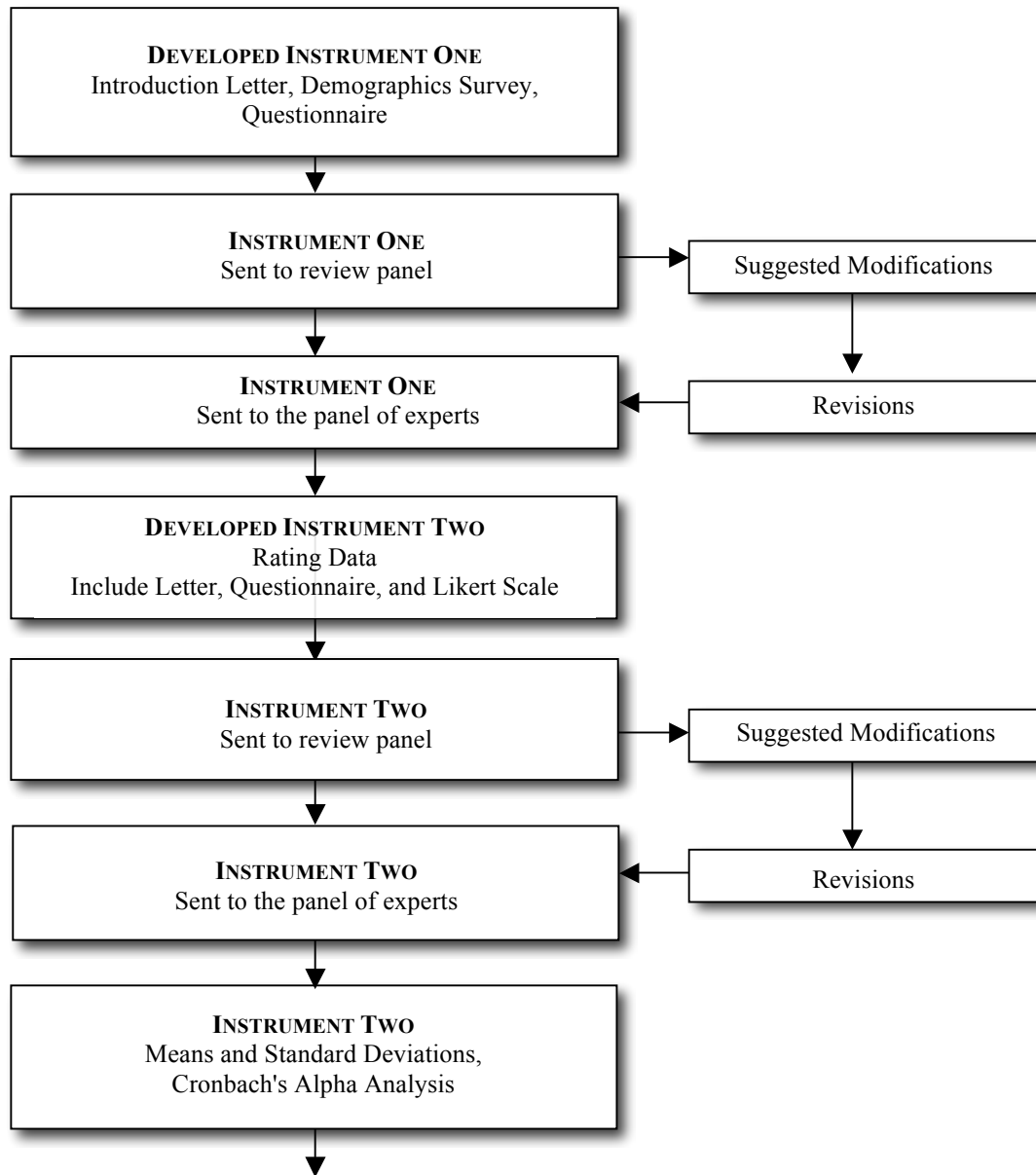
Round Two of the Delphi process included the rating of the results tabulated from Round One. The questionnaire for Round Two was developed and forwarded to the review panel for verification prior to being sent to the expert panelists. Each component aggregated from Round One was placed in random order on the questionnaire. Panel experts used a Likert Scale ranging from one to five, acknowledging agreement or opposition for each component. After examining the data and determining the means and standard deviations for each component, the Cronbach's Alpha analysis was employed. This analysis was used to determine which components were retained or extracted for the Round Three questionnaire.

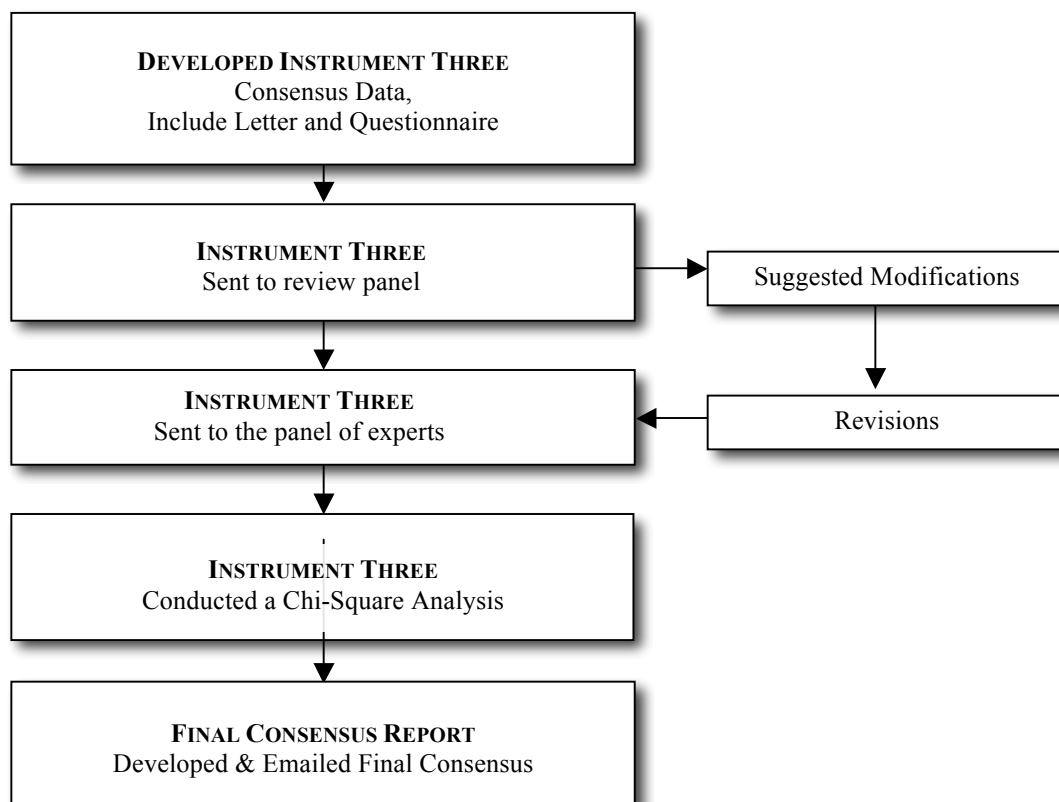
Round 3

The concluding round in the Delphi process, Round Three, outlined the components from Round Two that received greater consensus from the rated responses provided by the panel of experts. Upon approval of the concluding questionnaire from the review panel, the final instrument was made accessible to the panel of experts for responses. Expert panel members were asked to accept or reject each component from the results collected in the previous round. After this set of data was collected, a Chi Square analysis was employed and presented in a contingency table to illustrate the relationships between components. This concluding list was kept as the inventory of best practices for designing online environments for 3D modeling courses in engineering graphics education. Figure 1 presents an outline of

the research methodology associated with the Delphi method, as well as the statistical analysis required for this study.

Figure 1. Outline for Research Methodology





DEFINITION OF KEY TERMS

Delphi Method: the Delphi method is a process for structuring anonymous communication within a larger group of individuals, normally geographically dispersed, in order to achieve consensus among group members (Linstone & Turoff, 2002).

Web-based Delphi: a Web-based Delphi designed to be distributed and utilized using the Internet and the World Wide Web as the primary source of data collection (Andrews & Allen, 2002).

e-learning: technology-based learning that electronically delivers instructional materials to remote learners through computer networks via the Internet (Zang, et al., 2004).

Online instruction: a form of distributed learning of classroom instruction centered on the learner that utilizes the Internet as a medium of instructional delivery (Mccombs & Vakili, 2005).

Distance education: courses delivered to students that are not present in the same location as the instructor (Neal & Miller, 2005).

Self-directed learning: the individual assumes responsibility for formulating their learning needs by selecting, managing and implementing individual learning strategies in which this process prepares them for lifelong learning (Knowles, 1975).

CHAPTER SUMMARY

With technology rapidly emerging, today's learners have been altered by a technological revolution (Ferguson, 2001), fueling an inevitable modification in contemporary learning. In order to establish any novel or revised course of study, past curricula should continuously be examined to bring about reform (Clark, 2003). Unlike the

classics in education, online learning environments are the areas of study that are constantly evolving. As graphics educators, working with ever changing technology, standards, and guidelines, one must be capable of identifying current trends and issues, and have the ability to adjust as necessary.

Although technology has penetrated our society, and over the last several years the number of online degree programs and courses in the United States have dramatically increased, (Bonk, Magjuka, & Shi, 2005) most of the higher educational systems in engineering graphics education have gone virtually unchanged. Witty ways to use computers in the traditional classroom setting is no longer the most effective method of teaching graphics to all students (Ferguson, 2001). Felder (1996) suggested that teachers should learn to teach around a cycle, which builds upon the way learning is enhanced and presented. For that reason, engineering graphics education curriculum developers and/or administrators should explore and offer the possibility of new and innovative ways of delivering instruction.

Online environments are based on a learner-centered framework and create a platform for self-direction that can be conducive and supportive to the learner, as long as it has been well developed. When designing online instruction, learner-centered principles determine direction of curricula and practices (McCombs & Vakili, 2005). Current technological tools have been designed in such a way that implementation hurdles for online learning have been reduced, thus making the technology an excellent tool for facilitating online instruction. Although the advances of technology have made it possible for online course delivery, it is the content, design, and implementation of such courses that will be further investigated in this study.

CHAPTER 2: REVIEW OF LITERATURE

The purpose of this literature review was to provide information that supported the research questions guiding this study. The research questions pertained to the identification of best practices for designing modeling courses for online environments. In order to accomplish this task, five major bodies of literature that addressed the research questions were reviewed. These bodies of literature included a brief history of graphics instruction, theories of adult learning, online learning and online pedagogy, the information processing theory, and interactive technologies.

BRIEF HISTORY OF GRAPHICS INSTRUCTION

Graphics has long been a language within itself, containing orthography, grammar, style, idioms, and abbreviations (French, 1976), and throughout time has been the method in which engineering prefers to communicate in order to successfully convey and generate design ideas (Barr, 2004). Over the last two decades the profession of engineering graphics has witnessed major shifts in the programs of study as well as the content areas being taught. With the introduction of computer technologies, engineering graphics education has been significantly influenced, not only altering the curriculums, but also the instruction of individual courses (Barr, 2004; Clark, 2001). Considering these technological innovations, it is essential that engineering graphics education moves forward (Harris & Meyers, 2007) and considers alternative methods of instruction to reach broader populations of learners (Wiebe, 1992).

Throughout the history of graphics, pictorial representations dating back to 2130 B.C. represented the earliest known visualizations created to convey information and solve

problems (Harris & Myers, 2007; Barr, 2004). Graphical images such as these communicated thoughts, outlined methodologies, and provided forms of record keeping (Scribner & Anderson, 2005). These technical representations have served as the most fundamental method for exchanging and reconciling ideas (Wiebe et al., 2004). Historically, technical graphics instructors taught manual drafting utilizing paper and pencil drawings, drafting boards, T-squares, triangles, and a variety of French curves (Harris & Myers, 2007; Barr, 2004) and into the 1990's these tools were still being utilized.

Drawings such as two-dimensional (2D) projections were used to communicate information about existing or planned physical three-dimensional (3D) objects (Barr, 2004; Company, Piquer, & Contero, 2004; Bertoline et al., 1995). Descriptive geometry such as plane, solid, and analytical geometry were developed “as a series of projections with enough accuracy and robustness to serve as the basis of communication for the design and manufacture of complex, highly engineered objects and structures” (Batchelor & Wiebe, 1995, p. 3). Because 2D projections were illustrated on flat planes, Batchelor and Wiebe expounded by stating that teaching was much more about the practice of one's drawing and superiority of the lines. Out of this practice, multiple single views of objects were developed. Given these multiviews, however, the trained observer must align the views to create a mental representation of a 3D model.

Following pencil drawings was the emergence of computer-aided drafting tools (CAD). These tools computerized and automated manual drafting processes, but drafting modifications were achieved based on each individual line of the object (Chester, 2007). Following the integration of CAD, more intuitive computer-aided tools, which have allowed

3D objects to be created and examined, were introduced in engineering graphics education. Despite the evolution of computer-generated models and their life like representations, learners often found it difficult to comprehend 3D models (Scribner & Anderson, 2005) and traditional 2D instruction was not effective in describing the models. Wiebe (1991) offered one approach to increasing the learners' ability by beginning instruction with a physical 3D object or a 3D object in space, selecting a stationary viewpoint, and rotating the object in minute increments, pausing between each view. Mackenzie and Jansen (1998), and Bertoline (1991) proposed that the use of CAD tools provides opportunities for the technical instructor to design and manipulate 3D models in order to enhance individual learning.

Solid Modeling Instruction

Within the last two decades educators in engineering graphics have transitioned from manual drafting, to electronic 2D drafting, to 3D modeling instruction as previously mentioned. First introduced into the engineering graphics education curriculum in the early 1990's (Barr & Juricic, 1992) modeling has increasingly become a vital component in design and manufacturing in both education and industry (Rossignac, 2007; Rossignac & Requicha, 1999). Solid models are identified as a digital representation of the geometry or shape of an existing and/or envisioned physical or rigid object (Rossignac, 2007; Rossignac & Requicha, 1999). Because of the rapid growth of the use of solid models, many post-secondary engineering graphics education programs have converted from traditional 2D drawing and have implemented modeling practices into the curriculum (Ault & Giolas, 2005). With the revising of curricula across many programs, the challenge presented is not only reaching a level of consensus on a common curriculum within the engineering graphics education

community, but also deciding on the most effective instructional methodology needed to meet the needs of the global learner. Considering the 3D model as its core (Branoff, Hartman, & Wiebe, 2002), which includes but is not limited to solid modeling, instruction utilizing online collaborations (Branoff & Hartman, 2002), and web-based interactions (Connolly & Maicher, 2003; Maicher & Connolly, 2003) should be considered.

Upon examining traditional content for engineering graphics programs and 3D modeling curriculums for 21st century teaching and learning, Ault (1999) concluded that there exist a need for these curriculums to place greater emphasis on solid modeling concepts, parametrics, and modern graphical analysis methods. She also stated that engineering graphics educators should continue to teach common topics such as visualization, and with significant changes in technology, alternative methods of instruction utilizing interactive technologies should be considered. In a survey given to graphics faculty concerning topics in a modern engineering graphics curriculum, Barr (1999) noted that 3D visualization and modeling, as well as more traditional topics such as dimensioning, sketching, engineering drawings, and section views be included. The survey also reported that participants rejected topics such as descriptive geometry and geometric construction methods that are manually performed.

In a re-examination of 3D solid modeling courses for introductory engineering graphics Branoff, Hartman, and Wiebe (2002) proposed topics such as visualization, sketching, solid modeling, constraint-based modeling, geometry, dimensioning, multiviews and pictorials, manufacturing processes, working drawings, sectional views, auxiliary views, and assemblies of solid models all to be included in a solid modeling course. They further

stated that although the topics to be covered in a solid modeling course suggested a more drawing-centered design the overall goal of a solid modeling course is based on creating and extracting information from models, the decision making processes associated with the creation of models, and the development of techniques or strategies associated with the purpose of specific model creation.

After careful consideration of the content for a solid modeling course, Barr (1999) raised the question about how multimedia can be used in engineering graphics as well as the Internet. He also inquired about innovative technologies to be used in engineering graphics curriculums. Paralleling these notions, Connolly and Maicher (2003) at Purdue University began development of web-based instructional tutorials for engineering graphics education. As mentioned by Scribner and Anderson (2005), students often lack understanding of 3D models and if given 2D views of particular models still find it difficult to comprehend. The creation of these tutorials by Connolly and Maicher (2003) were guided by students' inability to visualize and comprehend multiple views of a solid model. To combat this issue, the web-based tutorials provided students with in depth explanations of multiview concepts such as projection theory, line types and precedence, principal views, and view development. Students were also given various types of models and more difficult multiview drawings to practice with. The interface for the tutorial was based on three sections: a tutorial introduction, the learning module for the tutorial, and a master test section.

After an evaluation of the original tutorial, Maicher and Connolly (2003) developed several iterations of the tutorial utilizing various interactive technologies and interface designs. According to Connolly and Maicher (2005) the creation of an interface designed to

be interactive with the ability to respond to student input served to be one of the most critical elements for student comprehension. This interactive tool allowed the learner to create each multiview instead of merely selecting the corresponding view for the model. The addition of this tool provided the learner with a greater sense of efficient and practical learning (Connolly & Maicher, 2004). They concluded by stating that increased efficiency with online instruction of this magnitude should be more dynamic and data-driven, which includes storing and retrieval databases, tracking, surveys, and online usability tests.

Howell (2003) of Lawrence Technological University also developed an online introductory 3D modeling course for a mechanical engineering student studying abroad. After eliminating paper from his engineering graphics courses, Howell began using Blackboard to post all course assignments, activities, and exams. He also used this learning management system (LMS) to display grades, comments or explanations, and CAD markups. Further usage included the Blackboard assignment manager to receive drafting files, CAD parts, and assemblies. Having used Blackboard for traditional courses, Howell recognized the potential capabilities of the LMS and utilized it for online instruction. In addition to Blackboard, Howell used synchronous technologies such as Gradepoint, for live demonstrations, two-way communications, and shared applications. Gradepoint is a web-based system used as a means for remote computers to communicate via two-way audio and video conferencing as well as screen and application sharing. Howell concluded by stating that based on this experience 3D modeling and engineering graphics can be successfully taught at a distance with the implementation of modern technologies.

In an effort to meet the needs of the multimodal learner, encourage self-directed learning, and determine the most effective methods for delivering instruction to students, Branoff and Wiebe (2008) developed and implemented a hybrid introductory 3D modeling course at North Carolina State University. Although the participating sections of this course met once a week in a face-to-face setting to address issues too difficult to handle in the online environment, course instruction including all course materials and assessments were delivered completely online. Earlier versions of this online course included a course website used to disseminate course content. Along with the course website, WebCT Vista was employed to assess student's knowledge of the content. Given that engineering educators depend on live demonstrations of software applications (Totten & Branoff, 2005), instruction was therefore distributed online via voiced-over-PowerPoints, and sketching and modeling demonstrations used streaming audio and video. Although these instructional delivery methods were utilized in earlier versions of this course, as an ongoing study with the purpose of improving instructional methodology and delivery, future improvements included the development and usage of the Moodle LMS for course material and assessment, as well as an automated system for evaluating modeling files (Branoff & Mapson, 2009a; Branoff & Mapson, 2009b).

The work done by Connolly and Maicher (2005, 2004, 2003), Howell (2003), and Branoff and Wiebe (2008) are three distinct, yet similar demonstrations of utilizing multimedia and the Internet for the online instruction of 3D modeling courses; each of which directly correlate with the question raised by Barr (1999) concerning how the use of multimedia and the Internet can be used to facilitate online learning for engineering graphics

education courses. Engineering graphics education, including 3D modeling curriculums have continuously evolved throughout time as previously noted. As society becomes more interwoven and involved in individual responsibilities, convenience becomes paramount. Paralleling this evolution, the transition and natural progression of engineering graphics education should move along with 21st century technology innovations (Harris & Meyers, 2007). These innovations include a transformation of teaching methodologies; methodologies such as online instruction and learning that will ultimately ensure the effectiveness and sustainability of engineering graphics programs (Ault, 1999) in post-secondary education.

THEORIES OF ADULT LEARNING

Brookfield (2002) stated "the belief that adult teaching should be grounded in adults' experiences, and that these experiences represent a valuable resource, is currently cited as crucial by adult educators of every conceivable ideological hue." Since it's inception as a professional field of study during the 1920's, adult education or how adults learn, has been researched and theorized by academics and practitioners (Merriam, 2001). Researchers such as Merriam (2001), Draper (1998), and Knowles (1975), to name a few, have made assertions about the characteristics and theories of adult learners. But what has been widely recognized is that no single theory is a representation of adult learning theory. "What we do have is a mosaic of theories, models, sets of principles, and explanations that, combined, compose the knowledge base of adult learning" (Merriam, 2001b, p. 3).

Although Merriam suggested that a multitude of theories, models, etc. represent adult learning theory, many of these theories are based on the work of Malcolm Knowles.

Introducing the term andragogy as the art and science of helping adults learn (Knowles,

1975), Knowles theorized that adults have distinct characteristics of learning, much different from that of children. These learning characteristics are shaped by the quality and magnitude of individual experiences, as well as the ability to manage and organize learning environments and learning processes.

Considering this notion, in order to effectively design modeling courses that address the needs of the adult learner and provides guidance for the development of online courses, it is necessary to look more closely at self-directed learning, experiential learning, and the learner-centered framework. Understanding the principles of adult learning that govern each of these theories may possibly assist instructors in becoming more effective facilitators of learning (Collins, 2004).

Self-Directed Learning

Self-directed learning as described by Knowles (1975) refers to the process by which the learner takes the initiative to acquire and construct knowledge, establish individual learning goals, obtain the necessary resources to help accomplish those goals, and determine the most appropriate methods to recognize individual achievements. Coinciding with Knowles (1975), Lee and Gibson (2003) categorized self-directed learning as having three dimensions: control, critical reflection, and responsibility. They described control as the ability to seize ownership of individual learning through interdependence, proficiency, and resources. Further defining the individual characteristics of control, Lee and Gibson (2003) stated that interdependence vocally contributes to how one chooses to learn, that proficiency is one's cognitive and metacognitive ability to construct knowledge, and that resources

include individual support from the community of learners, facilitators, and the technologists associated with a specific topic.

Critical reflection is defined by one's ability to construct personal meaning about an area under study, but is only often applicable to specific domains or content areas (Lee & Gibson, 2003). As described by Brookfield (2002) however, this dimension also has three interrelated processes. The first process mentioned, pertained to the adults' ability to inquire, review, and possibly reinstate assumptions that had formerly been identified as insignificant. The second process stated that adults revisit and gain perspectives on ideas, procedures, and interpretations that were previously rejected. Lastly stated, was the fact that adults come to recognize the influence of culture and its affect on perceptions in the global society. The third dimension described by Lee and Gibson (2003) characterized responsibility by one's willingness to learn and actively participate in the process of learning.

In support of Knowles (1975), and prior to Lee and Gibson (2003), Ferguson (2001) and Doolittle (2003) emphatically affirmed the importance of recognizing that learners build new knowledge on the footing of what has been previously learned, therefore constructing knowledge through a process of discovery. Baxter, Elder, and Glaser (1996) found that adept learners have the ability to construct logical explanations of subjects, and devise and employ strategies and solutions for more intricate problems, while being self-directed in their own learning.

With technology rapidly emerging, today's learners have been altered by a technological revolution (Ferguson, 2001) that creates opportunity for them to learn or work separately from others therefore promoting a self-paced environment. This type of

environment allows learners to teach themselves along with guided exploration or teacher facilitated processes (Clark, 2003; Ferguson, 2001). Felder (1996) mentioned that teachers should learn to teach around a cycle that builds upon the way learning is enhanced and presented. Lieb (1998) followed with the concept that adult learners need to feel free to direct themselves and that adult learners have established values and beliefs, pride, and a deep need to be self-directed. Levine (2001) asserted that the courses teaching technical information contained learners that were chiefly independent or self-directed. Also stated, was that these courses had substantial experience to draw upon, containing topics that directly affected one's developmental stages. Additionally, these courses provided intrinsic motivation, problem solving opportunities, and current and immediate applicability of information.

Each of these researchers assertions directly aligned with the principles of adult learning, as first defined by Knowles (1975) and later outlined by Collins (2004). Collins (2004) concluded the following: adults have accumulated a foundation of life experiences and knowledge, adults are autonomous and self-directed, adults are goal-oriented, adults are relevancy-oriented and practical, adults (all learners) need to be respected, adults are motivated to learn by both intrinsic and extrinsic motivation, adults learn best when they are active participants in the learning process, not all adults learn the same way, adults learn more effectively when given timely and appropriate feedback and reinforcement of learning, and adults learn better in an environment that is informal and personal.

So how is this applicable toward the development of online modeling courses for post-secondary education? When developing courses for online learning, it is crucial to gain an understanding of the learner by looking closely at the demographics of the learners, the

principles of adult learning, learner characteristics, and strategies for teaching, motivation, and interaction. Adult learning is built on recognizing preexisting knowledge, and life experiences of the adult learner. Effective educators or facilitators acknowledge and value this prior knowledge, and recognize that individuals have various levels of responsibility and other time commitments (Collins, 2004).

Experiential Learning

As evident with self-directed learning, one's individual experiences most often highly affect the areas one chooses to study. Therefore one's experiences are transferred into knowledge (Kolb, 1984). Kolb (1984) affirmed, "learning is a process whereby knowledge is created through the transformation of experience" (p .38). Influenced by the works of notable scholars such as John Dewey, Kurt Lewin, Jean Piaget, William James, Carl Jung, Paulo Friere, Carl Rogers and others, Kolb's experiential learning theory is a holistic model of the experiential learning process and a multilinear model of adult development (Kolb, 1984). Kolb proposed that the theory is built on six propositions, which are shared by the scholars previously mentioned (Kolb & Kolb, 2005). The six propositions are outline in Table 1.

Table 1

Experiential Learning Theory - Kolb & Kolb

Description

Learning is best conceived as a process, not in terms of outcomes. This proposition affirmed that learning should be a meaningful and engaging experience that provides continuous feedback on the efficacy of the complete learning environment.

All learning is relearning. Kolb and Kolb stated that the most effective facilitated environment encourages learner participation through disclosure of individual beliefs and ideas. This process of interaction provides opportunity for one's thoughts to be analyzed, examined, and integrated with more contemporary and refined ideas.

Learning requires the resolution of conflicts between dialectically opposed modes of adaptation to the world. It is through the sharing of thoughts and discussion of opposing views that determine and shape the learning process. During this process, forward and backward movement between "opposing modes of reflection and action and feeling and thinking" (p. 194) occur.

Learning is a holistic process of adaptation to the world. Learning goes beyond cognitive ability integrating all areas of the individual thinking, feeling, perceiving, and behaving.

Learning results from synergetic transactions between the person and the environment. Here Kolb and Kolb reference Piaget's writing concerning the occurrence of learning through the "equilibration of the dialectic processes of assimilating new experiences into existing concepts and accommodating existing concepts to new experience" (p. 194).

Learning is the process of creating knowledge. This final proposition is built on the notion that learning can occur through social interactions and this information is transformed into personal knowledge.

In experiential learning theory, the acquisition of knowledge transitions through a cyclical model of learning that consists of four independent stages. Independent stages represent the notion that the exchange of knowledge can occur during any stage (Kolb & Fry, 1975), however the stages must be consecutively followed and will ultimately include all

four modes (Hay Group, 2005). These stages are defined as concrete experiences, reflective observation, abstract conceptualization, and active experimentation.

Concrete experiences (*feeling*) focus on learning through individual and specific experiences. These experiences are viewed through the lens of one's feelings opposed to one's thinking. These feelings are based on how one relates to the position and needs of others, while being sensitive to the emotional needs or the actions of others. Reflective observation (*watching*) identifies learning through careful observation or watching the actions of others before making judgments. This stage places emphasis on having or obtaining knowledge as opposed to the application of such knowledge. It is concerned with looking for and considering alternative meanings to varying situations and viewing issues from diverse perspectives. Abstract conceptualization (*thinking*) primarily focuses on learning by logically evaluating ideas and concepts. This stage emphasizes thinking as opposed to feeling and is concerned with systematic planning, and acting on rational decisions concerning specific situations. Lastly, active experimentation (*doing*) focuses on learning by active participation, and emphasizes application as opposed to reflective observation. It is based on one's ability to accomplish tasks that may include taking risk associated with specific tasks, and influencing people and situations through one's actions.

As mentioned earlier, Felder (1996) stated that educators should learn to teach around a cycle and should adapt their teachings around the learner population. As Kolb (1984, 1975) indicated in his writing, learning is a continuum of knowledge building that is attained through several cycles of learning. When developing for online environments, designers, facilitators or educators, should view this approach to learning in the same manner. If

designed environments consider only one aspect of learning, important ideas and experiences may be neglected (Hay Group, 2005).

Connor (2007) wrote that an effective learner would recognize information, reflect on the ways in which this information will affect our life, evaluate how this new information will align with personal experiences, and contemplate how this information affects individual actions. She further mentioned that we integrate all these actions and without this integration individuals become passive participants in learning, minimizing higher cognitive functions and the incorporation of new knowledge into the schema. She emphatically stated that the knowledge that is acquired should be put into action in some form.

Considering this, having specific knowledge of learner characteristics serves to be of major importance in online environments for the educator/developer and the learner. It helps the developer in designing the most effective learning environments for learners based on their individual learning aptitudes. It also helps the learner identify the areas in which they can strengthen (Hay Group, 2005).

The Learner-Centered Framework

As educational reform continues to sweep across college and university campuses, a need continues to exist regarding the validity and overall effectiveness of online learning. Online environments are based on a learner-centered framework and create a platform for self-direction, which can be conducive and supportive to the learner as long as it has been well developed. When designing online instruction, learner-centered principles determine direction of curricula and practices (McCombs & Vakili, 2005). Additionally, knowledge of the factors that influence individual learning must be understood.

In 1990, the American Psychological Association (APA) appointed an exceptional Task Force on Psychology in Education to address this issue. The purpose of this elite group of individuals was to develop a framework that incorporated theoretical principles gained from psychology and education that could be utilized for educational reform (McCombs & Vakili, 2005; McCombs, 2001). At the conclusion of this process a document was drafted, *Learner-Centered Psychological Principles*, that identified twelve principles, later revised to include fourteen principles, outlining many influences that may affect individual learning experiences (APA, 1997, 1993).

As summarized by McCombs and Vakili (2005) from the 1997 APA Work Group of the Board of Educational Affairs, and illustrated in Table 2, the fourteen learner-centered principles are categorized into four distinct research-validated domains that can be applied to online learning.

Table 2

Learner-Centered Psychological Principles

Cognitive and Metacognitive Factors

Principle 1: Nature of learning process

The learning of complex subject matter is most effective when it is an intentional process of constructing meaning from information and experience.

Principle 2: Goals of the learning process

The successful learner, over time and with support and instructional guidance, can create meaningful, coherent representations of knowledge.

Principle 3: Construction of knowledge

The successful learner can link new information with existing knowledge in meaningful ways.

Table 2 (continued)

Principle 4: Strategic thinking

The successful learner can create and use a repertoire of thinking and reasoning strategies to achieve complex learning goals.

Principle 5: Thinking about thinking

Higher order strategies for selecting and monitoring mental operations facilitate creative and critical thinking.

Principle 6: Context of learning

Learning is influenced by environmental factors, including culture, technology, and instructional practices.

Motivation and Affective Factors

Principle 7: Motivational and emotional influences on learning

What and how much is learned is influenced by the learner's motivation. Motivation to learn, in turn, is influenced by the individual's emotional states, beliefs interests and goals, and habits of thinking.

Principle 8: Intrinsic motivation

The learner's creativity, higher order thinking, and natural curiosity all contribute to motivation to learn. Intrinsic motivation is stimulated by tasks of optimal novelty and difficulty, relevant to personal interests, and providing for personal choice and control.

Principle 9: Effects of motivation on effort

Acquisition of complex knowledge and skills requires extended learner effort and guided practice. Without learners' motivation to learn, the willingness to exert this effort is unlikely without coercion.

Developmental and Social Factors

Principle 10: Developmental influences on learning

As individuals develop, they encounter difference opportunities for and experience difference constraints on learning. Learning is most effective when differential development within and across physical, intellectual, emotional, and social domains is taken into account.

Principle 11: Social influences on learning

Learning is influenced by social interactions, interpersonal relations, and communication with others.

Table 2 (continued)

Individual-Difference Factors

Principle 12: Individual differences in learning

Learners have difference strategies, approaches, and capabilities for learning that are a function of prior experience and heredity.

Principle 13: Learning and diversity

Learning is most effective when differences in learners' linguistic, cultural, and social backgrounds are taken into account.

Principle 14: Standards and assessment

Setting appropriately high and challenging standards and assessing the learner and learning progress-including diagnostic, process, and outcome assessment-are integral parts of the learning process.

When approaching course development utilizing a learner-centered framework, the preceding domains offer learning practices and principles from a research-validated perspective (McCombs & Vakili, 2005). From these principles the following definition for learner-centered emerges:

“Learner-centered” is the perspective that couples a focus on individual learners-their heredity, experiences, perspectives, backgrounds, talents, interests, capacities, and needs-with a focus on learning-the best available knowledge about learning and how it occurs and about teaching practices that are most effective in promoting the highest levels of motivation, learning, and achievement, for all learners. The dual focus then informs and drives educational decision-making. Learner centered is a reflection in practice of the

Learner-Centered Psychological Principles-in programs, practices, policies, and people that support learning for all (McCombs & Whistler, 1997, p. 9).

Affirming McCombs and Whistler's definition of learner-centered, Bonk and Wisner (2000) followed by stating that the pedagogical strategies encasing the learner-centered approach references the needs of the learners including their individual learning styles. Bransford, Brown, and Cocking (1999) also defined a learner-centered framework from the context of cognitive structures and the pre-existing knowledge of the learner.

With that in mind, developing modeling courses for online learning employing the learning-centered approach implies that course developers must consider the learners' prior knowledge, experiences, interests and needs, all of which point towards learning. The learner-centered approach forces the instructor to consider the design of the online environment, language, and types of expression used to understand, interpret, and construct new forms of knowledge. The learner-centered approach also helps to identify the best teaching and instructional design practices that increase motivation, thus achieving higher levels learning.

Although research has been collected pertaining to a learner-centered framework that addresses the needs of the learner, it is also necessary to denote that what defines a learner-centered approach for teaching and learning is not exclusively comprised of learner characteristics, instructional methodologies, or agendas (McCombs & Vakili, 2005). Rather, learner-centeredness affects a class of individuals, including "the needs of the teacher, of the institution, of the larger society that provides support for the student and the institution, and often of a group or class of students (Anderson, as cited in Anderson & Elloumi 2008, p. 35).

Given the fact that learning is centered on many groups of individuals, Anderson (as cited in Anderson & Elloumi, 2008) argued that learner-centered should be referred to as learning-centered.

Research has also shown that the learning-centered approach is enhanced if applied in a context where collaboration between instructor/facilitator and other individuals involved in the learning offers supportive environments. Furthermore, learning is improved when learners possess feelings of ownership and autonomy over their own individual learning processes and can exchange that knowledge with others in protected learning environments (McCombs, 2003; McCombs & Whisler, 1997). This feeling of connectedness provides support towards online environments.

ONLINE LEARNING & ONLINE LEARNING PEDAGOGY

The transformation of education is due in part to the onset of online learning environments. The blending of such courses into the curriculums of colleges and universities is increasingly altering the context in which these programs design and implement courses in preparation for student need and future growth. Hiltz and Turoff (2005) mentioned that online learning is beginning to serve as a complete alternative method to attaining an education over learning at a distance and the traditional face-to-face class. Supporting the judgment of Hiltz and Turoff (2005), Smith, Ferguson, and Caris (2002) suggested that online delivery of instruction could provide to be a useful educational tool. They further suggested that online instruction fosters more in depth levels of discussion; therefore providing a more meaningful learning experience.

Anderson's Model for e-Learning

In order to provide adequate information about designing online environments specific to engineering graphics education and modeling, Anderson's Model for e-learning (2008) will be utilized. This model illustrates all the components necessary for designing online environments (Figure 2) and identifies the interactions of learners and teachers with one another as well as the course content.

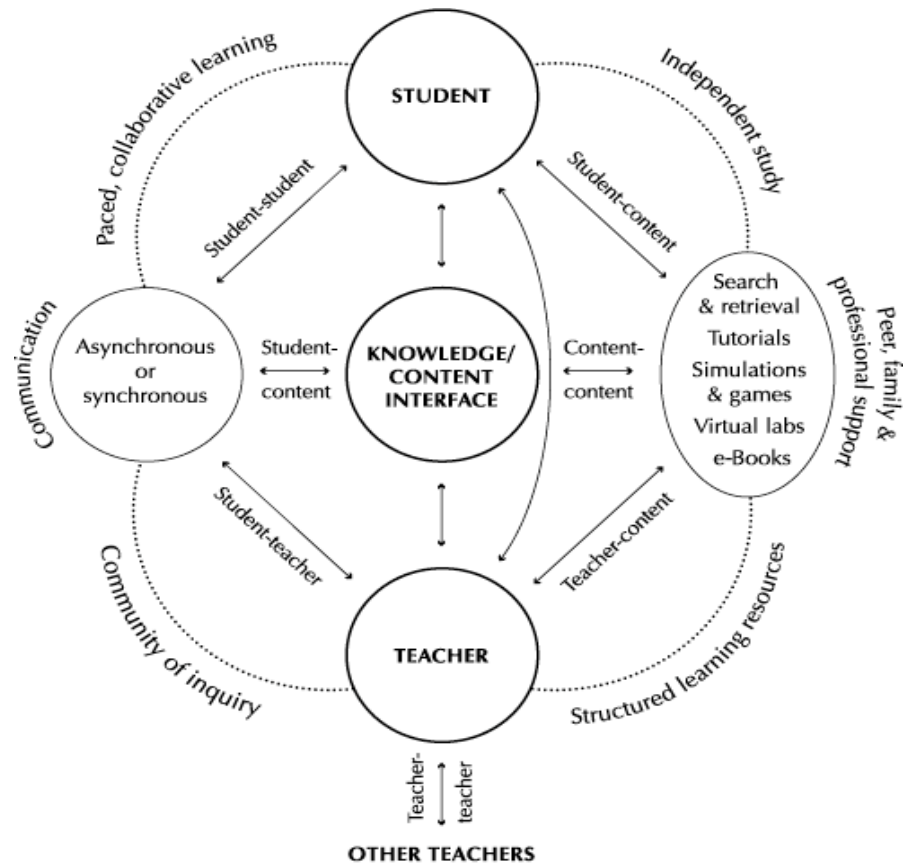


Figure 2. Anderson's Model for e-learning. Reprinted from *Theory and Practice of Online Learning* (p. 61), by T. Anderson, 2008, Edmonton, ABJ: AU Press. Copyright 2008 by AU Press. Reprinted with permission.

Based on Anderson's model (2008) the following interactions emerge:

Table 3

Anderson's Model for e-Learning - Identifying Interactions

Interaction	Description
Learner-technology	Interaction allows students to interface with the environment in which learning is taking place. For an online course, the technology would be the computer, web sites or online learning systems that provide access to course content or other individuals enrolled in the course (by using the computer for contact).
Learner-content	Interaction with online course materials, including components of the lessons, articles, course activities, and/or course test and evaluations. Learner-content interaction also includes virtual labs and computer-assisted tutorials. This type of interaction provides opportunity for students to construct their own knowledge of subject matter often leading to a more meaningful learning experience.
Learner-learner	Interactions consist of the relationships that learners in the online course build with one another. This interaction can take place with or without the presence of the course instructor.
Learner-context	Interaction allows students to apply what they have learned in order to work towards solving a real life problem or situation in order for the construction of personal knowledge and deeper understanding of that information.
Learner-instructor	Interactions help to establish teacher presence in online environments. This type of interaction provides students with opportunity to build relationships with the instructor. Learner-instructor interaction includes any type of assistance, counsel, or support the instructor provides to the learner towards the construction of new knowledge.
Instructor-Instructor	Interactions refer to professional development and support from other colleagues.
Instructor-content	Interactions focuses on the creation of the instructional content and learning activities within the online environment.

Table 3 (continued)

Interaction	Description
Content-content	Interaction consists of self-automated interaction with other automatic information sources providing up-to-date, real time information.

Anderson (2008) stated that when using this model it is necessary for teachers as well as course developers, to make imperative decisions about the facilitation of instruction. Upon consideration of these interactions, the learning outcomes most favored, determines the types of learning activities to be designed in the online environment (McCombs, Vakili, 2005; Prensky, 2000). Anderson (2008) further suggested that by outlining the interactions anticipated and provided for learners through the model, one can accordingly plan and make certain that a suitable blending of learner, instructor, and content interaction is designed for and represents each learning outcomes.

Anderson's model also hinges on instructional frameworks identified as learner-centered, knowledge-centered, community-centered, and assessment-centered. According to Anderson, a learner-centered framework is based on the coupling of two ideas, the individual and the learning. This type environment values individual learner experiences and considers the learners' prior knowledge and experiences, interests, and needs. A learner-centered environment supports individualized and community based instruction and instructors develop alternative methods of instruction based on those experiences. A knowledge-centered framework provides opportunity for learner's to construct new knowledge structures and transfer that knowledge to unfamiliar areas. A major goal in this framework is for

learners to find meaning in the information they are collecting and making sense of through reflective practices and exercises. Given this, courses are designed to promote creative and critical thinking in order to prepare them for life-long learning. The community-centered framework is based on the establishment of a community of learners through collaborative and individual interactions. Interactions can occur synchronously or asynchronously in multiple formats such as discussion boards or threaded discussions. Lastly, Anderson identifies an assessment-centered framework that is used to evaluate the learner's knowledge, motivate and inform the learner, and provide feedback to the instructor. Assessments can be formative or summative in that selection is based on course content, learning objectives, and goals. Additionally, results from an assessment-centered framework can provide information for the modification or revision of a course.

As mentioned earlier, online learning tends to be developed from a learner-centered framework. However, based on the need to include feedback, assessment, and reflection, Anderson suggested that the greatest challenge is not designing online environments from a learner-centered framework only, but to design environments that are “simultaneously learning-centered, content-centered, community-centered, and assessment-centered” (p. 54). He continued his thoughts about instructional frameworks by stating “there is no single, right medium of online learning, nor a formulaic specification that dictates the kind of interaction most conducive to learning in all domains with all learners. Rather, teachers must learn to develop their skills so that they can respond to student and curriculum needs by developing a set of online learning activities that are adaptable to diverse student needs” (p. 34).

Anderson's Model for e-learning illustrates many of the variables associated with

designing online environments that create meaningful and engaging experiences for the learners. The challenge when designing these environments is to determine the approach to learning, the methods, activities, and individuals that will be most affected by the learning environment.

Designing Online Learning Environments

Transitioning from traditional instruction to online instruction requires the consideration and knowledge of many factors. Teaching in an online environment is not merely just utilizing a different medium to deliver instructional material, “the medium itself has a transformative effect” (Otte & Benke, 2006, p. 24). As cited in Anderson's (2004), *Theory and Practice of Online Learning*, Davis stated that:

Any system is built in a context, and for any online learning endeavor, each discipline, department, faculty, institution, or company will have a mandate, a mission, specific goals, and values that have to be considered when planning and designing an ideal system. For a real system, even at this conceptual level, there will be many other internal and external environmental factors, such as competing priorities, budget constraints, professional group requirements, and so on. All of these factors must be well understood and accounted for at the outset.

All teaching and learning systems should be built on two foundations: the needs of the intended students, and the learning outcomes of the course or program (i.e., the knowledge, skills, and attributes that students want). An

ideal online learning system will be based on a plan that flows from a full understanding of these two fundamentals. (p. 98-99)

Upon consideration of these factors, a framework for online learning emerges. It is this framework for an online learning system that will govern the development of the online learning environment. Additionally, Davis (2008) mentioned that in an ideal online learning environment, whether it be through the developer or facilitator, the learning outcomes should be translated into course content, supplemental resources, and cultivate instructional practices and learning processes that facilitate and enable student achievement.

In relation to the effectiveness of online learning systems, Rao (2005) identified nine critical factors that could affect the delivery of instruction. These factors are identified as user-friendly navigation, built-in security systems, high levels of interactivity utilizing a multitude of collaboration tools, interactive sessions using streaming audio and video rich multimedia and graphics, transfer of knowledge from faculty and other learners, feedback from faculty and other learners, online exams and certifications, robust content management systems, and technological support.

In online environments, instruction can be delivered to the learner by two methods: asynchronous communications and synchronous communications. Asynchronous learning is typically described as the anywhere, anytime education. When using technology in online environments, the facilitator is actively involved with the learners, structuring course topics, providing assistance and facilitating group interaction amongst the learners. Asynchronous communication tools include blogs, email, discussion boards, online quizzes, streaming audio and video, narrated slideshows, learning objects, and website links (Totten & Branoff,

2005). Given that asynchronous communications represent an anytime, anywhere learning environment, the main advantage rests in the capability of accessing information at anytime (Ashley, 2003). Synchronous communication permits learners to connect to a course in real-time, often from remote locations. One advantage of synchronous communications is that while the lecture is being broadcast to the learners, audio and video streams of course material are archived for retrieval (Latchman, et al., 1998). Types of synchronous communication tools are audio conferencing, screen and application sharing, web conferencing, text chat, video conferencing, and white boarding (Ashley, 2003). Totten and Branoff (2005) stated that these tools help build collaborative learning environments or communities of practice.

Instructor Presence

Important to the success of online courses is the role of the instructor in this learning environment. Palloff and Pratt (2001) argued that in adult learning the educator's role is one that hinges on a learner-centered approach by permitting learners to construct their own knowledge. They also denoted that teaching in this context requires educators or facilitators of online instruction to move beyond the traditional face-to-face-pedagogy and become knowledgeable of a more relevant one.

According to Anderson (2008), and based on the theoretical model of Garrison, Anderson, and Archer (2000), effective teaching in online environments contains three critical components: cognitive presence, social presence, and teaching presence. Based on Garrison, Anderson, and Archer's (2000) community of inquiry model, cognitive presence is determined by the growth and development of critical thinking skills. Social presence is

particularly concerned with establishing a cohesive, supporting environment where learners are comfortable and secure about expressing their views in a collaborative context. Lastly, teacher presence, which is considered to be the most critical, is determined by the instructor's active participation and engagement in the learning environment.

The writings of Anderson, Rourke, Archer, and Garrison (2001) identified three vital roles that are necessary for the creation of effective teacher presence. They identified the design and organization of the learning environment, the creation and implementation of engaging activities, and the addition of subject matter expertise. Anderson et al., (2001) continued by affirming that the first opportunity for instructors to demonstrate their teacher presence is in the overall design and construction of the course content, the learning activities, and the assessments. With the advancements in technology, instructors of online learning can make revisions to courses based on the needs of the learners. Therefore, the most effective online educator provides opportunities of negotiation for learning activities and content, while continuing to motivate, instruct, and support the learning environment.

Anderson (2008) also identified three qualities that define an admirable online instructor. He stated that the online instructor is one that has sufficient domain knowledge, is enthusiastic and motivating, enjoys working with learners, has pedagogical (and androgogical) understandings, and is equipped with learning activities that can be implemented at any time. He expounded by suggesting that an online instructor will also have technical skills, which can be utilized to navigate and effectively make contributions within the online learning context. Lastly, the online instructor should maintain a level of

“resilience, innovativeness, and perseverance” (p. 290) that is classically defined as “pioneers in unfamiliar terrain” (p. 290).

Collaborative Learning

One of the greatest challenges when beginning online courses is the concern of establishing relationships with course facilitators and colleagues (Addesso, 2000). Hewson and Hughes (2005) stated that:

Online learning environments offer efficient ways of interconnecting group members and satisfying their communicative needs. However, learning does not proceed through shared communication alone; all groups imply social processes and learning groups demand an additional pedagogical intention. Popular online learning systems satisfactorily enable the management of students and teaching staff but offer limited tools to support familiar educational techniques and even fewer to support the essential processes of group dynamics that accompany learning. (p.1)

They also stated that learners have a need to establish their identity, acquaint themselves with others, contribute to group communications, and develop supportive and trust worthy relationships with others (Hewson & Hughes, 2005). This type of online communication named community of practice or collaborative learning, identifies learners as active and engaged participants contributing to group activities (Hiltz, 2005). Interactions promote the exchange of knowledge, and driven by the responses of others, knowledge is constructed (Alavi, 1994). Interactions, whether learner-learner, learner-instructor, learner-content, etc., promote higher levels of cognitive learning (Rovai, 2002; Wegerif, 1998), thus having a

positive affect on the learning experience (Woods & Baker, 2004). Avis and Fisher (2006) suggested that engagement in these collaborative communities is viewed as a key element in adult learning.

Aligning with the ideology of Kolb's learning modes (1984) and varying context's of Anderson's Model of e-learning (2008), Pask's conversation theory (as cited in Hewson & Hughes, 2005), provided opportunity for collaboration, rich dialogue, and higher cognitive processes. According to the conversational theory of Pask (1976), vital moments occur in learning and serve as pedagogical processes of learning. The model of conversational theory identifies discursive interaction, interaction with a microworld, adaptation of action, and reflection on action as the four moments in the learning process that occur in microworlds or task spaces. For online learning, microworlds are defined as the virtual spaces where learners actively participate, become engaged with concepts, and work in practical ways to solve problems (Hewson & Hughes, 2005).

Pask (as cited in Hewson & Hughes, 2005) described discursive interaction as educational processes in higher education that most often seek to amend the thoughts of learners about the views of the world, and for the most part, alter their ideas about how these aspects are to be appropriately theorized and described. Additionally, prescribed dialogue in a class must focus on student thought and fallacy, and it must be able to draw on individual learner experiences of the phenomena under study. The second moment outlined is the interaction with a microworld. Within this moment instructors establish problem spaces to offer learners a setting for secure action on, and experience of, the phenomena under study. Within these spaces learners work towards attaining designated goals. The microworld itself

provides intrinsic feedback on the contributions and actions of the learner within it. Thirdly, the adaptation of action moment, Pask explained, suggests that instructors must adapt the microworld or problem space regardless of the continuing theoretical discussion and activities of the learners within the microworld. At any time, the structure of the problem space, the designated goals, or the feedback given, can be altered. Furthermore, learners should modify their responses and actions based on the feedback they receive from others, and on the enduring theoretical discussions. Lastly, reflection on action provide opportunity for both the instructors and learner to reflect on the events that have taken place in the microworld and include the outcomes of these reflections into ongoing theoretical discussion.

Given that conversational theory offers additional information about the goals of collaborative learning environments, Laurillard (1993) stated that an adequately developed fully online educational design must provide support for each of these moments. Since the overall goal of collaborative environments is to stimulate communication amongst the instructor and the learners in order to construct new knowledge, the online course must be facilitated in such a manner that promotes these interactions. To facilitate learning in this way, instructors must be aware of the learner's thoughts, misunderstandings, and understandings of students. Although discussion within this context of learning can encourage higher levels of thinking, Dreyfus (2001) suggested that online learning does not provide the necessary information to promote expertise, only proficiency. Hewson and Hughes (2005) argued "in the social sciences and particularly with regard to the theoretical skills typical of university learning, mastery may be achieved without the intimacy of the classroom or studio or the physical presence of a master" (p. 110). They elaborated by stating

that in undergraduate courses, the goals are to provide a meaningful learning experience for the learner and assist them in acquiring knowledge, but higher levels of expertise are typically not set as outcomes.

Assessment

Assessment seems to be one of the most difficult items to gauge in online learning environments. Often used interchangeably with evaluation, assessment as defined by Reeves (2000) is the quantifier of student learning while evaluation reviews the overall effectiveness of a completed program. According to Rosenkrans (2000), assessment greatly influences the material learners are presented and the methods by which that material is delivered. This therefore represents the cognitive aspects of learning. Rosenkrans further stated that assessment also impacts the conditions under which the learning will take place as well as the amount of information to be covered or received which is identified as the operative aspects of learning.

Conventionally, assessment has often been referred to as test or quiz, or a summative or formative evaluation. Summative assessments are most often used to measure some form of memorized learning (Popham, 2002) while formative assessments assist in the modification or revising of a course to address the current needs of the learner (Boston, 2002). Assessment provides instructors and learners with the information necessary to determine whether or not the learner is proficient in the area under study (O'Reilly & Newton, 2002). As a result based on learning outcomes, the instructor can modify subsequent course activities, suggest practices that may be used to lessen difficult areas, or provide information to the learner that allow for individual self-correction or progression towards

more intricate course study (Dochy & McDowell, 1997). Assessment in any form, however, should align with the content of the course, as well as the learning objectives and goals for the course.

According to Wilson (2004), and Buzette-More and Alade (2006), assessment evolves over time and must always be conscious of surrounding circumstances and actions. When utilizing assessment to evaluate student learning during class instruction or in e-learning environments, Wilson (2004) also stated that assessments diagnose and respond to immediate learning needs, determine learning outcomes for outside purposes such as grading, selecting, and system accountability, inform the learner about progress, needs, and current understanding, and adjust and improve resources for current and future users. When viewing assessment as measurement, Falchikov (2005) stated that this traditional approach to learning does not prepare the learner for life long learning and goes against the very nature of the purpose of education itself (Burke, 1969). Wright (2004) therefore suggested that a transformation of learning and assessment should occur, altering assessment practices from memorization testing to critical thinking. In a reevaluation of assessment, Angelo (1995) affirmed that:

Assessment is an ongoing process aimed at understanding and improving student learning. It involves making our expectations explicit and public; setting appropriate criteria and high standards for learning quality; systematically gathering, analyzing, and interpreting evidence to determine how well performance matches those expectations and standards; and using the resulting information to document, explain, and improve performance.

When it is embedded effectively within larger institutional systems, assessment can help us focus our collective attention, examine our assumptions, and create a shared academic culture dedicated to assuring and improving the quality of higher education. (p. 7)

When considering the assertions of Angelo, as well as the methods by which an instructor formulates assessment tools, Anderson (as cited in Anderson & Elloumi, 2008) stated that when an instructor is effectively present within the learning environment, their presence would command specific and detailed dialogue concerning the criteria in which individual learning will be assessed. Anderson expounded by stating that an instructor that develops and maintains a presence of flexibility, trepidation, and compassion will reflect these characteristics in their approach to assessment.

Chen et al., (2009) acknowledged that within the context of online learning, learners have the ability to acquire knowledge at anytime and anywhere. With this daily spectrum of time, instructors may not be available to answer questions or assist learners in better understanding the course content during their time of need. Considering this, instructors should utilize assessment methods that can serve not only as knowledge measurement, but also as reflective practices for learners in this environment. One should assert the use of authentic assessments that utilize reflective practices to not only assist learners in their understanding of the course material, but to also help learners make associations about related concepts, ideologies, and practices (Rule & Bajzek, 2009). Authentic assessments, as defined by Rule and Bajzek (2009), provide direct exploration by students and examination of student performance on realistic intellectual tasks modeled on real world situations and

activities. They also stated that authentic assessments require students to be effective performers with acquired knowledge, presents students with a full array of tasks, and involves loosely structured challenges that help students transition to the complex ambiguities of professional life. Through this process of assessment, learners are given real world problems to discuss and solve.

Automated Assessments for Modeling & Sketching

Upon reflection of reflective practices within authentic assignments and assessments for an online solid modeling course one main question arises, how do we assess student performance in an online environment that primarily utilizes sketches and the creation of solid models as the main components of student performance? In a series of studies conducted by Connolly and Maicher (2005, 2004, 2003) pertaining the use of web authoring applications for the development of web-based engineering graphics tutorials, assessment methods for evaluating the successful creations of orthographic projections evolved into an interactive real-time drawing and response tool that provided immediate feedback to students about their drawing progress. In an effort to increase learner skills and graduate towards a level of mastery, Connolly and Maicher (2005) developed and tested this revised tool on eighty introductory engineering graphics students at Purdue University. Based on the results from the utilization of this tool, they also suggested that continued usage of this tool would further quantify its validity and usefulness.

When considering sketches, Fan (2007) suggested the use of online sketching tools to capture student drawings. These drawings can then be assessed using an automated system that reviews student sketches in comparison to the instructors work. Fan and Tanimoto

(2007) identified an automated assessment system that allowed students to freely draw graphical representations or input text, while also having the ability to grid snap. During the drawing process, the sketching tool recorded all events, therefore making mistakes more easily identifiable. In order to adequately assess the students' drawings, the instructor inputs the solution drawing. In an explanation of this particular automated assessment system, Fan and Tanimoto (2007) stated the once a student completes the online drawing the sketching tool assessment system performs a diagnostic on the student work in comparison to the solution drawing. Based on the overall results the instructor can determine if the student successfully completed the sketching tasks. The instructor can also review the sketch recordings to conclude where the student may have had difficulty in completing the drawings. In addition to assessing student knowledge, retention, and ability utilizing performance based assessments and instructor feedback, additional strategies that promote the use of reflective practices can be employed such as self-assessments, peer assessments, and selected and/or constructed responses.

Self-Assessments

Self-assessments, as earlier mentioned by Dochy and McDowell (1997), allow learners to self correct or independently determine their skill and knowledge level. Through this process, learners have the ability to measure their progress and achievement (Robles & Braathen, 2002) therefore gaining a greater understanding of areas needing improvement (Organero & Kloos, 2007). Self-assessments serve to be self-reflective, a means by which learners can examine their performance (Longhurst & Norton, 1997) ultimately contributing to their own individual learning processes and their abilities to be lifelong learners (Larres,

Ballantine, & Whittington, 2003). In a collaborative context, self-assessments provide opportunity for learners to identify their individual contributions towards the community of learners (Kayler & Weller, 2007).

Kayler and Weller (2007) conducted a study to assess the benefits of self-monitoring and online discussions that foster independent learning. Through this analysis they determined that self-assessments assist learners in better understanding themselves and the dynamics of group discussion. Kayler and Weller further noted that self-assessments enlighten learners on the value of their contributions to the community of learners and provide insight on methods by which discussions and activities can be improved.

Kemppainen and Hein (2008) favored the use of self-assessments when they determined that the first-year engineering students that utilized self-assessments increased their examination scores by 7-13% and on average received a 6% higher final grade than those that had not participated in self-assessments. Upon examination of self-assessment for knowledge construction in online asynchronous discussion, De Wever et al., (2008) utilized self-assessment for first-year instructional science students as a reflection tool leading towards more meaningful learning while simultaneously encouraging self-directed learning. Although they found that self-assessments did not significantly increase knowledge construction, they attributed this to the lack of understanding the value of self-assessments and the absence of self-assessment training as identified by McDonald and Boud (2003).

Peer Assessments

Because online learning often employs collaborative activities as a part of the learning process, peer assessments can also be utilized as an informal approach for assessing the

quality of learning taken place within a collaborative context (Keppell et al., 2006). Used within a community of learners through discussions, group activities, projects, and social networking, peer learning is a bi-directional process (Keppell et al., 2006) that promotes lifelong learning (Tan, 2003). Because the goal of assessment is most often used as a tool to measure ones acquired knowledge, peer assessments in online learning can more commonly be used to provide feedback not only about individual contribution, but also about individual growth through collaborative participation (Liu & Carless, 2006). Liu and Carless (2006) mentioned that this feedback is about “rich detailed comments...that can lead to enhanced understandings and improved learning” (p. 280), learning which can ultimately be assessed by the instructor.

Looking more closely at the effects of peer assessments, Xiao and Lucking (2008) conducted a study for the development of an online writing project collaboratively authored by the students. For the peer assessments instructors designed a rubric meeting specific criteria for students to use during their assessments; a peer assessment based on a quantitative-only feedback methodology and a quantitative-plus-qualitative feedback methodology. The study results indicated that students that participated in the quantitative-plus-qualitative feedback peer assessments improved their writing. Ertmer, et al., (2007) investigated the impact of peer feedback on the quality of online discussion postings. Within a quantitative context, they determined that peer feedback made no significant contribution to the quality or improved the quality of online postings. However, students asserted that peer feedback assisted them in attaining a greater understanding of course material while reinforcing newly acquired knowledge.

Selected & Constructed Responses

As defined by Jordan and Mitchell (2009) selected responses are classified as multiple-choice assessments that are used to measure student knowledge. Selected response assessments are most often employed in larger courses (Nicol, 2007; Johnstone & Ambusaidi, 2000) because of the ease of grading, the testing of multiple topics within a single exam, and the ability to control for diverse writing abilities and styles which are often associated with constructed response assessments (Fellenz, 2004). Constructed responses, alternatively, are those that require written responses or short answers to questions without the assistance of prompts or supporting information (Jordan & Mitchell, 2009). Nicol (2007) stated that selected responses are predetermined, designed for instructor efficiencies, and are based on recognition and memorization rather than knowledge presented in written form. The issue often presented with selected response assessments is that instructors are never sure why a student has chosen a specific answer (Johnstone & Ambusaidi, 2000). According to Johnstone and Ambusaidi (2000) this raises questions about the students' actual knowledge base; are students certain about the material they are responding to or making educated guesses? Considering this, there is constant debate on whether or not selected response assessments should be used (Fellenz, 2004).

Formative Assessments

Additionally, assessments should also be used to motivate, inform, and provide feedback to the instructor about the course (Bransford, Brown, & Cocking, 1999). Williams et al., (2006) asserted that online assessments are most useful when they align with instructional goals or generate information helpful towards the development of the overall

course. Therefore, if appropriately designed or thoroughly rooted in the development cycle of programs and curriculums (Nicol & Macfarlene-Dick, 2006) these assessments should provide information for course modification or revision. Nicol and Macfarlene-Dick (2006) also stated that formative assessments should be viewed as an essential element in course instruction and student learning in higher education.

In an effort to reform or rethink assessment in higher education, Nicol and Macfarlene-Dick (2006) outlined seven broad principles for good feedback that educators should consider when developing or modifying courses for higher education. These principles could be transferred to the online environment as well. These practices include a course facilitator that fosters the development of self-assessment (reflection) in learning, encourages teacher and peer dialogue around learning, and helps clarify what good performance is based on goals, criteria, and expected standards. Additionally, Nicol and Macfarlene-Dick (2006) stated that a course facilitator should provide opportunities to close the gap between current and desired performance, deliver high quality information to students about their learning, encourage positive motivational beliefs and self-esteem, and provide information that can be used to help shape teaching.

OVERVIEW OF INFORMATION PROCESSING

Visual Literacy

At the core of graphics is the ability to understand, interpret and create imagery that effectively conveys graphical information. Graphics also helps to strengthen one's power and ability towards improving the constructive imagination, perceptive ability, and visualization skills. French (1976) stated that the ability to maintain a constructive imagination, housing

mental images and expressing those images to others is a necessary requirement. Felton (2008) followed years later by stating that the core of visual literacy is one's ability to identify or acquire meaning from images. Therefore, the importance of engineering graphics education delivered in the traditional setting of classroom instruction or in an online environment lucidly lies in one's ability to visually communicate and understand the use of visual thinking and literacy skills.

As a process of depicting graphical communications, visual literacy includes the ability to successfully decode visual messages and compose significant and meaningful visual communications. It also houses a set of competencies that allows individuals to interpret visual content, and examine and discuss the purpose and social impact of those images (Bamford, 2003), especially when the authenticity or validity of an image is in question. Visual literacy has also been defined as the ability to construct meaning from images, therefore utilizing visual thinking, which represents an "intuitive and intellectual process of visual idea generation and problem solving" (Brumberger, 2007, p. 380) and a "thoughtful and sustained form of understanding" (Bamford, 2003, p. 2). Visual thinking exercises critical thinking and are developed through exposure of thought provoking graphical representations of simple and complex data. The strengthening of visual thinking skills in engineering graphics education is contingent upon one's ability to process graphical representations using higher order learning or simple-to-complex sequencing.

As part of the cognitive domain, higher order learning in engineering graphics is based on a continuum of visual progression from simple to complex graphical data, which includes analyzing, evaluating, and creating images. This progression travels from visual

thinking (which includes manipulating and representing images), to visual learning (building graphical knowledge through visual interaction), and lastly visual communication (using imagery for communication) (McLoughlin & Krakowski, 2001). Facilitating learning from simple tasks and advancing towards more complex tasks (Merrienboer, Kirschner & Kester, 2003) enables the growth of multiple skills, ideas, and forms of expression to be refined.

Cognitive Theory and Visualization

Visualization has been an integral part of man's investigation of the world and as time progresses, advances in technology has allowed man to graphically communicate more accurately and increase visual thinking abilities. Today's educators and researchers are searching for new and innovative ways to visualize complex data in order to move beyond the status quo, while minimizing cognitive load (Metros, 2008). To fully accomplish this, an examination of the factors that influence cognition and shape the perceptive ability and visual memory must be conducted first.

Cognition originates from the Latin word *cognoscere*, which simply means to become acquainted with. In order to become more acquainted with data in any form, it is necessary to identify the factors that may affect one's ability to accurately conceptualize and interpret that data. Thus identifying the concept of representation as the core relationship between visualization and cognition (Osberg, 1997). The information, whether visual-pictorial or auditory-verbal, and one's cognitive abilities directly impinges on the visualized outcome of that data. French (1976) stated that the internal mental processes include memory, perception, retention, problem solving, etc. and that these processes can be shaped by one's experiences including education and environment. Additionally, understanding the variety of

metacognitive, cognitive, and social/affective strategies can improve visualization and learning. But the remaining question is how do individuals process information that has been acquired through sight or by hearing? To advance understanding the working memory in the human cognitive system is evaluated.

The working memory is where current mental activity occurs. It is also where information is stored and manipulated which is assumed to be an integral part of the human memory system (Baddeley, 1996). It represents a cognitive structure that is very limited in both capacity and duration (Simon, 1974). Based on this information, it is proposed that visualization extends the working memory by accessing stored information and creating associations. This process reflects the cognitive load theory, which seeks to explain how an individual appropriates levels of mental processing energy towards specific information (Cooper, 1990). This concept directly impacts the ways in which an individual views, stores, and retrieves images or sounds, thus affecting communication utilizing visual and spatial skills.

Miller (1956) argued that an individual could retain at least seven unrelated items of information. *The Magical Number Seven, Plus or Minus Two* divided information into chunks. These chunks served as categories for organizing information. The key to successfully chunking information, however, rested with the individual's ability to remember an identifier that linked all components together. As long as the rule can be applied, the size of the collection within the chunk makes no difference. Years later, Doolittle (2003) reported that a general principle of cognition is chunking. He stated that chunking facilitates a

multifaceted and integrated approach for organizing, processing and storing information in the memory.

Additionally, stored information or internal representations are considered to be mental models. The mental model exists in the mind and visualization is the external realization of the rendered mental model, thus shaping one's views. Because mental images are more fluid than visualizations, as problems become more complex it becomes increasingly difficult to construct and hold in working memory the views necessary to reach a desired goal. Therefore, the solution is to anchor at least some aspect of our mental models as visualizations. This process establishes mental associations with pictorial-visual or auditory-verbal images (Crapo, Waisel, Wallace, & Willemain, 2006), but solely depends on how the individual has coded or learned the information (Allen & Henik, 2002).

Paivio (1986) suggested that pictorial-visual and auditory-verbal images are filtered in different processing systems. He also suggested (1990) that words and images contained different cognitive representations, therefore causing the brain to utilize separate memory systems for each. Hitch, Woodin, and Baker (1989) also mentioned that the working memory has several subsystems or components to deal with different types of information: a visual-spatial component, a verbal or phonological component, an active component, and a passive component. In relation to these theories, Mayer and Moreno (2003) stated that cognition offers three theory-based assumptions about how people learn from words and pictures: the dual channel assumption, the limited capacity assumption, and the active processing assumption. The dual channel assumption identifies the human cognitive system as being two distinct channels for representing and manipulating knowledge; a visual-pictorial channel and

an auditory-verbal channel. Mayer and Moreno (2003) also stated the auditory-verbal channel processes verbal representations of words that enter the cognitive system through the ears. Words often evoke images therefore increasing the probability of remembrance and visualization of verbal material. This does not mean picturing the words in one's mind, but imagining the words as objects or ideas (Higbee, 1993).

The visual-pictorial channel, however, processes pictorial representations of images that enter the cognitive system through sight. With an increase of visual information comes an increase in complexity, therefore possibility leading to an increase in cognitive load as well. Visual complexity is a term that refers to the amount of information that an image contains which includes, lines, colors, tones and texture gradients (Gibson, 1979). When visual information is processed, cognitive load is affected by either greater visual complexity or the lack thereof. When there is a lack of visual complexity one's cognitive load is still affected given that mental energy has to be utilized to act as filler for the information not provided (Allen & Henik, 2002).

Visualization extends the working memory by establishing and manipulating verbal and pictorial associations. If the working memory is overloaded mental images are transformed into visualizations thus identifying the limited capacity assumption. The human cognitive system is also based on the active processing assumption, which leads to meaningful learning because learners engage in active processing within the channels. This concept establishes the idea of organization because it selects relevant words and images, and arranges them into coherent pictorial and verbal models, integrating them with each other. These active learning processes are more likely to occur when the working memory contains

verbal and pictorial representations at the same time (Mayer & Moreno, 2003; Mayer 2002). Because the working memory can house corresponding pictorial and verbal representations concurrently, the working memory is able to build referential connections between them (Moreno, 2001). Therefore, it is clear that working memory provides a crucial interface between perception, attention, memory, and action (Baddeley, 1996).

Paralleling the work explicated by Crapo et al., (2006), Mayer and Moreno (2003), and other researchers, Doolittle (2003) outlined several pedagogical and implementation strategies that can be utilized to improve and increase the effectiveness of teaching and learning in the online environment.

Table 4

Pedagogical and Implementation Strategies to Improve the Effectiveness of Teaching and Learning in the Online Environment

Interaction	Description
Assess prior knowledge	Assess prior knowledge using pre-instructional questionnaires, chat room or video conferencing conversations, essay/opinion writing, and interaction with simulations or intelligent tutors.
Focus students' attention	Using introductory activities and advanced organizers including online socialization through direct or indirect questioning, or posting of material to be discussed.
Pre-organize information	Organized information through comprehensible chunks utilizing email, video conferencing, electronic handouts, PowerPoints, multimedia modules and audio/video presentations.
Engage students meaningfully	Activities that engage deep, integrative, and meaningful processing such as web-based artifacts, online conversations, and examinations.

Table 4 (continued)

Interaction	Description
Self-generate knowledge	Individual knowledge construction using online reflective journals, video conferencing, writing assignments, simulations, semantic networks, mapping, or threaded discussions.
Monitor understandings	An explanation of thought through discussion, writings, or the creation of artifacts such web pages, portfolios, articles and videos.
Practice	Meaningful and deliberate practice throughout instruction employing web-based white boards, video conferencing, multimedia models, assignments, or simulations.
Timely Feedback	Informative feedback with comments and rubrics, as well as socialization techniques, or email voice messages.
Interact socially	Interaction amongst all participants using asynchronous, synchronous, or socialization tools.
Equate learning/performance contexts	Learning activities that mirror real world interactions utilizing synchronous communications, simulations, and live-time audio/video.
Expect individual differences	Because of individual differences web-based instruction provides multiple modes of instruction, representation, presentation, and interactivity.

Numerous scholars have discussed visual learning for decades, and as researchers and educators continue to study methods for improving visualization and understanding complex data, they must recognize and interpret the cognitive affects on visualization. The purpose of

this specific information was to identify ways in which cognition affects visualization and how the working memory houses current mental activity all of which ultimately affects the way in which instruction is designed.

Of additional importance was the recognition of methods or techniques that our minds cognitively utilize to demonstrate how visualization extends the working memory through accessing stored information and created associations. It was found that when the working memory experiences a cognitive overload, the association is created by capturing a mental model of thought, image, or auditory response and transferring it into a view or visualization based on the way in which the information was initially coded. Therefore when creating any type of instruction, specifically online instruction, one must consider the presentation including navigation, animated images or text, and the hue and layout of the material in order to minimize cognitive load and enhance visual and spatial literacy.

INSTRUCTIONAL & INTERACTIVE TECHNOLOGIES FOR ONLINE LEARNING

As engineering graphics educators, working with ever changing technology, standards, and guidelines, one must be capable of identifying current trends and issues, and have the ability to adjust as necessary. The educator must be capable of understanding the most recent software's and technologies that can enhance individual learning, and based on past and present technology theories and applications, understand its place and longevity in industry. Because today's learners are more self-directed and insistent on determining their personal learning experience, instructors in traditional and more specifically online environments must begin to revamp and remove outdated practices. Implementation of interactive technologies is at hand and institutions of higher learning should pay close

attention to how online learning programs presently employ these technologies (Beldarrain, 2006).

Because technology is rapidly evolving, more tools for interaction and collaboration on the web have been made available. Anderson (2008) described the web as a quickly changing mechanism that at one time was defined from a context of text-based communications, content, and interactions. However, with advancements in technological tools, the web can now be viewed as a mechanism that supports all forms of media. In this dynamic, web-based learning environment, content can be electronically constructed and tailored to meet the needs of the learner. It also helps to assemble web-based learning communities and provides opportunity for learning to continuously revolve around the designated learning tasks (McCombs & Vakili, 2005).

When published to the web online learning can integrate various types of technologies for synchronous or asynchronous communications. Chickering and Ehrmann (1996) outlined seven principles for such implementation based on good practices for teaching and learning. The principles included encouraging contact between students and faculty, developing reciprocity and cooperation among students, using active learning techniques, giving prompt feedback, emphasizing time on task, communicating high expectations, and respecting diverse talents and ways of learning. These seven principles, in accordance with the course learning objectives, will ultimately assist in determining the justifications for integrating specific technologies.

Web 2.0

With advances in technology and the rapid growth of online learning, the need to employ more interactive tools for learning has taken center stage. Utilizing the Internet as a tool for online learning and communication, in accordance with Chickering and Ehrmann's (1996), seven principles grant instructors the opportunity to rethink their instructional delivery. As the Internet continues to cultivate individual expression, it also promotes a forum for collaborative learning (Huffaker, 2004) through the use of social software or social networking tools. Rollett et al., (n.d.) defined social software as a shared medium that permits users to independently or collaboratively exchange knowledge and publish or display those thoughts utilizing the web. User-friendly applications, currently identified as Web 2.0, designed for networking within an online environment (Burgess, 2003) have added value to educational settings (Beldarrain, 2006), particularly those in higher education.

After the development of the first generation of social software, which included chat rooms and discussion boards, Beldarrain (2006) noted that the second-generation of Web tools would dramatically increase interaction. Collectively identified as Web 2.0 technologies, blogs, wikis, and podcasts, to name a few, are changing the landscape of social and professional networking and providing learners and educators the opportunity to generate information collectively through social interactions (Maloney, 2007). Unlike traditional methods of information distribution, Web 2.0 technologies, make sharing content expeditious (Dearstyne, 2007). It also permits users to not only be "consumers of information" (Cole, 2009, p. 141), but also publishers of information that can be in "partnership with others"

(Cole, 2009, p. 141). These technologies can be utilized unaided or in conjunction with other applications.

Web 2.0 technologies have significantly assisted in producing effective learning environments and establishing communities of practice in post-secondary education through continuous individualized interactions and group collaborations. The uses of these technologies are fostering knowledge construction through effective and communal learning, and individual publication, which support the pedagogical approaches to learning (Ferdig, 2007; Beldarrain, 2006).

Wikis

Wikis have become a major component of Web 2.0 technology (Parker & Chao, 2007). According to Carpenter and Roberts (2007), and Ajjan and Hartsthorne (2008), wikis are web sites that are designed for interaction and collaboration that permit multiple authors to write and modify information on the website. They can be instructor-managed or student-managed (Beldarrain, 2006). Wikis also have history and rollback functions (Anderson, 2008), which record individual modifications made to content, thus preventing undesired modifications (Cole, 2009).

Tonkin (2005) identified four areas in which wikis could be used. These areas include utilizing wikis as a single contributor/user, as a lab book, for collaborative writing, and as a knowledge repository. Tonkin stated that single user wikis could be used for concept mapping and reflection of one's personal thoughts and growth over time. Utilizing wikis as lab books provide users with an online reference that could serve as a research notebook consisting of ideas and concepts that could be shared with others. Collaborative writing is

also one of the main attributes of wikis which Tonkin identified wikis as the best place for individuals create and write collaboratively. Lastly, the creation of wikis serves as a knowledge repository that can be quickly accessed and as Cole (2009) stated, can aid as a supplement or extend course materials currently used.

Paralleling Tonkin's (2005) thoughts on collaborative authorship, Carpenter and Roberts (2007) stated that wikis could establish a sense of community in online environments. Lipponen (2002) acknowledged that wikis help to facilitate learner interactions and knowledge exchange, which can be used in the distribution of mass communications, and can provide a space for reflection. Alexander (2006) also noted that because the constructed information of wikis receives group modification and is reviewed by one's peers, in an educational environment this approach to knowledge acquisition provides support to individualized learning while equally promoting collaboration.

Given that wikis provide a space for collaborative learning, they help to establish a sense of community, therefore a community of practice (Cole, 2009). As earlier mentioned, communities of practice are created when a collective group of individuals exchange information in a shared domain (Parker & Chao, 2007). Schaffert, Gruber, and Westenthaler (2006), noted that wikis serve as a platform to aggregate information from those that participate in the community of practice collaborating and sharing interesting topics.

Weblogs

Blogs serve as a more personal way to present information on the web (Safran, Helic, & Gutul, 2007). Blogs are considered to be a grouping of writings that resemble personal journals that can be published to the Internet utilizing text or graphics (Huffaker, 2004;

Beldarrain, 2003). Kennedy (2004) suggested that blogs are most useful for exploring topics or enhancing writing and literacy skills which Lankshear and Knobel (2003) noted, serves as a way to keep track of ideas and findings that align with pedagogical practices and can be identified as a pedagogical instrument.

Huffaker (2004) affirmed the use of weblogs by stating that weblogs provided the greatest opportunity to integrate the use of innovative education technologies with sharing and voicing individual experiences. And much like the art of storytelling where language and reading skills begin to develop (Bransford, Brown, & Cocking, 1999), blogging is an excellent way to exchange information in courses. As noted by Wrede (2003) blogging provides a forum for educators and students to interact and exchange their thoughts on a shared platform, which encourages participants to produce knowledge and communicate individual perspectives candidly and incessantly. Blogging also provides a forum for those seeking assistance and support of their ideas while “nurturing the interconnecting of ideas, arguments and theories between participants in an emerging community of practice” (Baggetun & Wasson, 2006, p. 454). Weller, Pegler, and Mason (2005) followed the notion presented by Baggetun and Wasson (2006) about ideation assistance and support by stating that weblogs can be useful for learner portfolios because they help to organize and maintain individual growth, achievements, and personal reflections of things past. Safran, Helic, and Gutul (2007) also noted that the educational benefit of blogs include the promotion of critical and analytical thinking, the promotion of creative, intuitive, and associational thinking, the promotion of analogical thinking, the provision for increased access, and the exposure to quality information and solitary and social interaction.

In a study examining the use of weblogs to support personal study in a series of self-regulated learning courses, Baggetun and Wasson's (2006) findings parallel those presented by Safran et al.,(2007). They found that weblogs provided reflection for individuals in a public forum, which ultimately lead to deeper conversations about a topic, a compilation of relative links to assist in individual knowledge construction, the enhancement of critical thinking and problem solving abilities, and an individualized examination of personal knowledge.

Podcasts

Podcasts are media files published to the web using syndication feeds that automatically update episodes in a series upon release (Copely, 2007; Rappa, 2006). Given the advancements in media technologies, Copely (2007) noted that podcasts have become a common vehicle for the distribution of audio and video content in entertainment, music, news and education. Utilizing podcasts for e-learning assists in meeting the anytime, anywhere philosophy of learning and adds an additional modality of learning for students (Lee, McLoughin, & Chan, 2008).

Donnelly and Berge (2006) suggested that based on current literature, podcasts can be used in education to distribute course materials, to record live classroom activity, and to augment student learning. Drawing from Donnelly and Berge (2006), in a study outlining the rationale for the use of podcasts in education, Lee, McLoughlin, and Chan (2008) identified several benefits for educators and student such as peer-to-peer sharing, support of authentic learning and assessment, and the experience associated with the creation of personalized podcasts. Warlick (2005) also suggested that the creation of podcasts by students promotes

collaborative learning because learners can work in teams to study and examine a specific area or topic. Although podcasting is not specifically a synchronous activity, Beldarrain (2006) echoed that podcasts help to establish a sense of community in the same manner as blogs and wikis. In accordance with Chickering and Ehrmann's (1996) seven principles for good teaching in higher education, Fernandez, Simo and Sallon (2009) examined whether or not podcasting enhanced individual study in an online engineering course. Their findings suggested that podcasting, if used in its proper context as a complement alongside standard instructional materials for a course, improved personal course study. Additionally deduced, was that students had greater enthusiasm and motivation for class participation because podcasts increased the level of engagement between student-teacher relationships. Lastly they concluded that podcasts added an additional modality for learning.

Branoff (2007) stated that with the advancements in technology, the development of Learning Management Systems have been greatly influenced therefore making a variety of tools available for instructors to deliver instruction with a multifaceted approach. Technology has now become a central component to learning in online environments.

CHAPTER SUMMARY

This chapter reviewed five major areas that contribute to the development of online courses for modeling in graphics education. The first area under study, the history of graphics instruction, provided a brief overview of the evolution of teaching engineering graphics education courses as it relates to drawing, visualization and modeling. This section of the literature review helped to establish a background and present the need for this study.

The next section of the literature review outlined the theories of adult learning. When developing any course for adult learners, whether it is for traditional or online learning, it is necessary to understand the type of learner receiving the instruction. In order to gain a greater understanding of the adult learner, principles of adult learning-including self-directed learning, the experiential learning theory and the learner-centered framework were reviewed.

Part three of the literature review identified pedagogy related to online learning. Given that this information is utilized in an online learning environment, it was necessary to review terms and practices that are associated with online learning theory. The research study utilized Anderson's Model for e-learning, which identified components associated with learning in online environments. In addition to Anderson's model, pedagogical attributes of designing online environments, instructor presence, collaborative learning, conversational theory, and assessment were reviewed.

The fourth part of the literature review provided detailed information about the information processing theory, including visual literacy, and cognition and visualization. The purpose of this chapter was to gain knowledge on how information is processed in order to develop the most effective online course.

Part five of the literature review outlined interactive technologies that can be utilized to aid in the creation of a community of learners, as well as identifying individual contribution and growth in online learning environments. Technologies such as blogs, wikis, and podcasts were examined along with Chickering and Ehrmann's seven principles for technology implementation.

In conclusion, this chapter reviewed all major elements that were needed to develop introductory 3D modeling courses for online learning. Because designing online environments for 3D modeling has a limited history in graphics and online learning literature, there existed a need to contribute to the growing body of literature for this field.

As engineering graphics education programs have continuously evolved throughout time, the natural progression of these curricula is now toward online instruction. As society becomes more interwoven and involved in individual responsibilities, convenience and multi-dimensional learning has become paramount. Online instruction presents educational opportunities not only for self-directed adult learning, but also experiential learning, and an environment of learner-centeredness for knowledge construction.

Models for learning in the online environment have been developed with considerations of cognitive theory. Based on the literature, the conclusion drawn was that engineering graphics education programs have progressed not only in content, but also in interest as well, enough to facilitate and warrant online instruction. Current technological tools have been designed in such a way that implementation hurdles for online learning have been reduced, thus making online instructional delivery for 3D modeling courses in engineering graphics education possible.

CHAPTER 3: RESEARCH METHODOLOGY

THE DELPHI METHOD

The Delphi method was selected as the most efficient way to collect information for the inventory of best practices utilizing Anderson's (2008) model for e-learning as previously discussed in chapter 2. The information was collected from subject matter experts respective to their given fields of study. As we have noted in both chapter 1 and chapter 2, although a wealth of information exists on developing courses for online delivery, a list outlining the best practices for designing modeling courses for online learning is nonexistent.

Clark (2003) suggested that in order to establish any novel or revised course of study, past curricula must be continuously examined to bring about reform. Following, he expounding by stating that practice prepares individuals to look towards the future in order to shape it based on their current views. The forecasting technique that Clark suggested paralleled the overall goal of the Delphi method. The preparation and development of ideas for future utilization can be based on the collective opinion obtained from past and present experiences of panel members. Regarding this research study, the most up to date information was collected from knowledgeable experts (Stitt-Gohdes, & Crews, 2004) that have experience with online instruction in the field of engineering graphics education. This information was used to identify instructional and technological components essential for developing modeling courses for online delivery.

Over the years, educators and researchers alike utilized brainstorming activities to develop ideas or solve problems. Through those discussions and rounds of questioning, achieving group consensus, estimates, or solutions to complex problems was the overall goal

(Brown, 1968). Considering this type of general outcome, based on the classification of participants and the round-robin approach, the Delphi method was chosen as the data collection method for this study. Loo (2002) stated that it has a great ability to provide an organized process for collaborative communications, which is needed to reach consensus about a given topic. The Delphi method can also provide the exchange of more recent findings in the science and technology community than that which can be found from examining or searching through the literature (Delbecq, Van deVen, & Gustafson, 1975). Before moving forward with the research methodology for this study, a brief overview of the Delphi method was in order to more lucidly understand its abilities and usefulness for online course development.

Brief Historical Overview of the Delphi Method

The Delphi method was developed in the 1950's while Dalkey and Helmer of the RAND Corporation were conducting experimental research on defense strategies. The study, named Project DELPHI, sought expert opinions based on a series of reiterated questions regarding strategic planning about military bombs (Dalkey & Helmer, 1963). After demonstrating the usefulness of eliciting expert opinion and event forecasting, the RAND Corporation used the Delphi method for non-military purposes such as planning developing economies (Helmer, 1963). Since that time, the Delphi method has continuously been used to come up with new and innovative ways of doing things, as well as predict any changes that may occur (Clayton, 1997) in education, healthcare, and technology fields (Loo, 2002).

BRIEF COMPARISON OF GROUP DECISION-MAKING METHODS

In order to receive input from a diverse group of experienced and knowledgeable educators, it was necessary to include individuals in the panel of experts and the review panel with various backgrounds and perspectives. In an effort to find the most effective method for assembling these dissimilar ideas, three group-decision making processes were examined. Characteristics of the nominal group technique (NGT) and the interacting group method (IGM) were comparatively analyzed with the Delphi method.

Delbecq and Van de Ven introduced the nominal group technique in 1971 as an organizational planning method (Dobbie et al., 2004). The NGT provided an opportunity for panel members to assemble in the presence of one another to generate ideas and exchange ideas. Those ideas, however, were developed independent of other panel members, thus reframing from verbal interaction (Delbacq & Van de Ven, 1971). Additionally, the NGT utilized a monitoring team, which collect and organize each individual idea, and later presented those ideas to the entire panel. From the list of collated ideas, ranking or rating occurred and the panel rendered a decision based on statistical criteria (Clayton, 1997). This decision-making technique utilized a structured format for the generation and exchanging of ideas. When describing the effectiveness of the NGT, Delbecq and Van de Ven (1971) identified four subsequent steps for utilizing the technique. These steps included the following: privately generating ideas for a specific task or problem, silent or private nonverbal writing with the round-robin listing or presentation of ideas following, group discussion and summarization regarding the privately generated ideas, and private and nonverbal voting on priority items utilizing rating or rank ordering procedures.

Although the NGT was effective for establishing new ideas and finding specific areas of concern, the IGM was utilized for developing and synthesizing ideas, and also for expounding, amending, and reaching consensus about a particular task or problem (Delbecq & Van de Ven, 1971). During this forum panel members began with a problem that was introduced by the group leader (Delbecq & Van de Ven, 1971). Unlike the format of the NGT, the discussion employed in the IGM produced ideas in an unstructured way (Delbecq & Van de Ven, 1971), thus creating a forum for open dialogue (Clayton, 1997). During this process, panel members verbally exchanged ideas, provided feedback to one another, and analyzed individual work. This method of group decision-making was often referred to or identified as a conventional method of brainstorming for ideas in which the session concluded once consensus was obtained (Clayton, 1997).

Anonymity

Although the Delphi method employed elements of each decision-making method, upon comparison, the elements utilized were quite different than those of the NGT and IGM, and offered advantages beyond the other techniques (Loo, 2002). To begin, participants or panel members were not required to convene at a specific location for idea generation like that of the NGT and IGM. Given this, the Delphi method maintained the identification of the panel members throughout the rounds of questionnaires although the researcher may have known their identities. Anonymity, first stated by Dalkey in 1968, and affirmed by Linstone and Turoff (2002), offered anonymous communication that eliminated common biases, and group communications (Stitt-Gohdes, & Crews, 2004). This characteristic of the Delphi method also reduced the effects of dominant individuals and group pressure (Dalkey, 1972;

1968), which may often occur during face-to-face discussion (Clayton, 1997). Based on Dalkey (1967), a single outspoken individual of the group could have an enormous influence on the group opinion.

Additionally, panel members were most often geographically dispersed which provided anonymity and a level of confidentiality (Hsu & Sanford, 2007) that was not an attribute of NGT or IGM. Furthermore, anonymity eliminated interaction between panel members, which helped to increase the accuracy of the overall group (Woudenberg, 1991), as well as the effectiveness of the group's ability to identify issues and trends, and generate new ideas for any given topic (Stitt-Gohdes, & Crews, 2004).

Iteration and Controlled Feedback

Much like the NGT and the IGM, the Delphi method was based on a multi-stage iterative process of questions, often three or four rounds, submitted to a panel of experts by the researcher for response (Linstone & Turoff, 2002). When comparing the Delphi method to NGT and IGM it is important to note that expert panel members in each round of the Delphi respond to the questions independently and privately, unlike the other group decision-making methods.

During the first round of the Delphi study, the researcher submits open-ended questions to the panel of experts for consideration. The open-ended questions are used to elicit ideas and information specific to the content of the study (Andrews & Allen, 2002). The second round of questioning provides opportunity for the panel of experts to evaluate the items summarized from the first round. Participants of the study then review and possibly revise their responses (Brown, 1968) and rate or rank-order items in order to identify those of

most importance (Hsu & Sandford, 2007; Wicklein, 1993). This process also occurs in the NGT and IGM. This round of the study will generate feedback that will begin to demonstrate the move towards consensus of the expert panel. The third round of the study helps to achieve greater consensus about subject matter from expert panel members (Wicklein, 1993). This round of questioning provides expert panel members the opportunity to further clarify their judgments or address the summarizations of the previous round made by the researcher (Hsu & Sandford, 2007). Therefore, expert panel members reassess their individual responses in lieu of the group of expert panel members (Dalkey, 1968). A fourth round may be included to not only refine previous priorities based on the consensus derived through group opinion (Wicklein, 1993), but also to accept or reject the items collected from round three. Again, the primary goal of these rounds is to achieve consensus amongst the panel of experts regarding a specific task or complex problem.

Questionnaires for each round are developed based on the responses from the previous rounds, which are forwarded to the expert panel members in the form of summarizations (Dalkey, 1967). The main premise behind providing the responses of each member of the expert panel is to exchange and present the collected information (Woudenberg, 1991) so that an informed decision about the topic can be made. Dalkey (1967) termed this review type of information review, controlled feedback, which reduces the effects of noise. In the Delphi method, noise is described as a distorted communication of data, which ultimately generates biases unrelated to the task or purpose of the study (Hsu & Sandford, 2007; Dalkey, 1968, 1967). In comparison with both the NGT and IGM, the presentation of responses occurs publicly, therefore controlled feedback is not considered.

Statistical Group Response

Continuing to demonstrate why the Delphi method was selected over the NGT and IGM, it is important to consider how consensus is achieved. Although both the NGT and IGM reaches consensus through pooling outcomes (Delbecq & Van de Van, 1971), the Delphi method utilizes statistical analysis (Hsu & Sandford, 2007; Dalkey, 1968, 1967). Dalkey (1968) insisted that the use of statistical group opinion reduces levels of forced compliance amongst members, therefore reflecting the opinion of each contributor in the collective response. Hsu and Sandford (2007) echoed Dalkey by stating that the utilization of statistical analysis permits “objective and impartial analysis and summarization of the collected data” (p.2). Much different than the NGT and the IGM, the summarizations from each round follow the initial feedback from the round. Stitt-Gohdes and Crews (2004) identified Likert scales and analysis of those results via medians, means, and standard deviations, as some of the methods for obtaining feedback results during each round of the Delphi.

STRENGTHS & WEAKNESSES OF THE DELPHI METHOD

Selection of Experts

Research of any type requires knowledge of the strengths and weaknesses of the research methodology being utilized. Research professionals not only in education, but business and government have also critiqued the use of experts in Delphi studies. The Delphi method has been one of great debate over the last four decades and heavily critiqued about its methodology (Sackman, 1975).

Because a universal method for identifying experts is nonexistent (Keeney, Hasson, & McKenna, 2006) in the literature, the attributes that define an expert are unclear. In defining experts, Jairath and Weinstein (1994), however, identified them to be those that have current and related knowledge and insight on the topic under study, while remaining unbiased to the study results. Powell (2002) concurred by stating that selection of experts should be based on experience and knowledge in the areas under study, therefore exemplifying some level of credibility with others in their field. Hsu and Sandford (2007), in accordance with those previously mentioned, suggested that experts be well taught and adept in the specific area of knowledge necessary to formidably contribute to the issue.

To minimize concerns related to the selection of experts, the researcher should fully describe knowledge specializations and experiences of the expert panelist members (Kennedy, 2004). Murphy et al. (1998), following Linstone & Turoff (2002), affirmed that the advantage of using expert panelists rests in their abilities to contribute extensive knowledge and experience through each round of the Delphi study, therefore improving upon the decision-making process.

Anonymous Communication

Another element of the Delphi that has been heavily critiqued is its use of anonymous communication between expert panel members. Sackman (1975) criticized the use of anonymity by proposing that expert panel members could not be held accountable for the opinions and views expressed following each round of questioning. Woudenberg (1991) stated that anonymity might also lead to low compliance towards the completion of the study.

In contrast however, Dalkey (1972, 1968) concluded that anonymous communication reduces the effects of dominant individuals and group pressure. When describing the reasoning for anonymity, Turoff and Hiltz (1996) stated that individuals should not have to commit themselves to initial expressions for an idea that may not turn out to be suitable. They also declared that if an idea turns out to be unsuitable, no one loses face from having been the individual to introduce it, that persons of high status are reluctant to produce questionable ideas, that committing one's name to a concept makes it harder to reject it or change one's mind about it, and that votes are more frequently changed when the identity of a given voter is not available to the group. Turoff and Hiltz (1996) expanded their thought by also stating that the consideration of an idea or concept may be biased by who introduced it, and that when ideas are introduced within a group where conflicts exist in either interest or values, the consideration of an idea may be biased by knowing it is produced by someone with whom the individual agrees or disagrees. They concluded their list of reasons for anonymity by suggesting that the high social status of an individual contributor may influence others in the group to accept the given concept or idea and the lower status individuals may not introduce ideas for fear that the idea will be rejected outright.

Stitt-Gohdes and Crews (2004) followed Turoff and Hiltz's (1996) reasoning by suggesting that if those participating remain unidentified, their responses will be more open and honest. Kennedy (2004) also advocated anonymity by stating that the more prevailing, influential voices could lead to peer pressure, therefore possibly altering the outcomes. Considering this, consensus can be more easily achieved if participants remain anonymous (Westbrook, 1997). Although the Delphi continues to be a popular choice for group decision-

making based on anonymous communication (Keeney, Hasson, & McKenna, 2006) it is important to make expert panel members aware that they are making decisions with a group of individuals (experts) (Turoff & Hiltz, 1996) towards a common goal. This helps expert panel participants recognize that they are co-contributors in the study, therefore increasing and promoting interests, ownership, and active involvement (Kenney, Hasson, & McKenna, 2006).

Achieving Consensus

Another area of concern for the Delphi is the meaning of consensus or the lack thereof (Beretta, 1996). One of the goals of the Delphi method is to reach a level of consensus amongst expert panel members about a specific subject or topic under study. Conversely, there are very few guidelines that have been clearly outlined about the level or percentage of consensus the researcher should endeavor to attain (Kenney, Hasson, & McKenna, 2006; Linstone & Turoff, 2002) and often times studies refrain from providing a clear definition for the meaning of consensus (Powell, 2003).

In an evaluation of the Delphi, Woudenberg (1991) stated that although one may achieve high consensus it might not be a representation of high accuracy. Yousuf (2007) followed by suggesting that this high or accurate consensus may be erroneous. Kenney, Hasson, and McKenna (2006) affirmed the notion that it would be difficult to obtain 100% agreement amongst the panel of experts on all issues. Therefore, in order to refute any claim of erroneous consensus, Kenney, Hasson, and McKenna (2006) emphatically suggested that the researcher must determine the definition and level of consensus before beginning the study and using confidence intervals.

WEB-BASED DELPHI

Like most surveying instruments of the past, the Delphi technique is no different in that researchers utilized pencil and paper questionnaires for data collection (Colton & Hatcher, 2004; Turoff & Hiltz, 1996). Aggregating data using paper and pencil questionnaires meant that researchers must also post (or deliver) questionnaires to research participants. Considering the geographical distribution of all the participants involved in the Delphi study, mailing questionnaires may not only be costly, but also time-consuming.

Considering this, a new method for developing and processing Delphi studies was conducted during the 1970s. Data was collected utilizing a computer network or computer mainframes (Turoff & Hiltz, 1995). The primary goal for collecting data in this manner was three fold: expediency and convenience, the elimination of paperwork and parcel services, and the integration and utilization of current technologies. With the introduction of the Internet including a host of available open source Web technologies, geographically dispersed individuals are connected like never before. The most practical application of the Delphi now is to utilize the Internet for survey distribution and data collection. In support of this notion, Colton and Hatcher (2004) used the anytime, anywhere Delphi approach as a method for content validation in human resources development which resulted in deeper discussion amongst expert panel members.

The most practical advantage of using Internet technologies for conducting a web-based Delphi study rests in the researchers ability to more feasibly include participants that are distributed geographically. Although participants in the study are not selected based on demographic representation, having participants from varying regions or locations may

provide to be useful by means of possibly having knowledge, exposure, or accessibility to resources that others may not.

Andrews and Allen (2002) conducted a study utilizing a web-based Delphi to gather information about issues students should be aware of when working with a team project. From this study, they found additional benefits for conducting a web-based Delphi. These advantages parallel those that have been previously mentioned relating to the overall goal of the Delphi method. Andrews and Allen (2002) deduced that the use of email eliminates reproduction and mailing costs and that controlling the availability of the questionnaire by specifying an input time frame and removing access to the questionnaire allows the researcher to control the response period. They found that the ease of responding and the awareness of a time frame should result in a time factor reduction, especially if the use of a time frame is clearly explained in the initial correspondence that solicited participation. The results also found that utilizing a web-based Delphi eliminates human data entry, human influence is greatly reduced during the analysis phases, and the overall duration of the project may be reduced considerably.

Looking more closely at content validity for the adult online learner, Colton and Hatcher (2004) utilized a web-based Delphi to demonstrate how technology can enhance the traditional Delphi. They deduced that the web-based Delphi “yielded rich qualitative and rigorous quantitative data resulting in a content validated instrument, possibly resulting in a more in-depth content validation, applicable to educational, business, industrial, and government research” (p. 188). Therefore, the use of a web-based Delphi adds a convenience

component into survey response, which allows for the anytime, anywhere philosophy to be put into practice.

PANEL SIZE

As previously stated, Delphi studies require a panel of experts for survey responses, as well as a review panel for examining and evaluating the questionnaires. Although there has been debate on the minimum and maximum size for the panel of experts, Delbecq, Van deVen, and Gustafson (2002) suggested that within homogeneous populations 10 to 15 participants would be sufficient, whereas heterogeneous populations could have as few as 5 to 10 experts. Studies have reported expert panel sizes ranging from 10 to several hundred participants (Colton & Hatcher, 2004; Reid, 1988; Linstone, 1978).

In a study investigating the critical present and future issues in the area of technology education, Wicklein (1993) included 25 panelist geographically dispersed across 15 states as well as the District of Columbia. Pollard and Pollard's (2004) study on the areas in educational technology that will require research within the next five years utilized 30 professional experts from the field of educational technology. When looking more closely at the challenges teachers faced with the implementation of information and communication technologies in a project based environment, Kramer, Walker, and Brill (2007) included 103 participants selected from attendance rosters from the International Education and Resource Network Conference held in Slovakia.

Given this, what constitutes the most favorable number of expert panel participants is not clearly defined in the literature (Hsu & Sandford, 2007). The recommendation of Delbecq, Van deVen, and Gustafson (1975) emphatically stated that the size of the expert

panel should be as minimal as possible and will differ based on the context of the issue. To ensure that all views concerning the development of online courses for modeling are adhered to, educators in engineering graphics education were included on the expert panel. Based on the findings from the literature, it was proposed that a total of 24 panelists would be utilized for this study. Based on the results from the demographics survey, 29 expert panelists and three review panel members participated in this study.

RESEARCH METHODOLOGY

Selection of Participants for the Delphi Panel

Careful selection of the study participants was essential to the overall success and validity of the study (Stitt-Gohdes, & Crews, 2004). Yousuf (2007) stated, “the Delphi study is only as good as the experts who participate on the panel” (p. 87), therefore considerable thought and reflection must be given towards panel selection. Hsu and Sandford (2007) denoted that Delphi participants should be extremely competent and well qualified in the specific area of knowledge under study.

To address panel selection Delbacq et al., (1975) outlined four characteristics for the researcher to consider when selecting experts for the panel. They believed that in order to receive effective participation from respondents they must feel personally involved in the problem of concern to the decision makers, have pertinent information to share, are motivated to include the Delphi task in their daily schedule of competing tasks and lastly feel that the aggregation of judgments of a respondent panel will include information that they too value and to which they would not otherwise have access.

Paralleling the criteria Delbacq et al. (1975) suggested for panel selection, Kramer, Walker, and Brill (2007) chose expert panelists to participate in a study about project based learning initiatives, and integration of information and communication technologies based on their attention to the subject and noticeable commitment to the subject matter. The researchers also used two to three years of experience and location of participants as criteria indicators. They believed these qualifiers would provide meaningful information and insight for the study.

In a Delphi study conducted to investigate and identify the critical issues in technology education, Wicklein (1993) choose participants based on their involvement with national and state professional associations as well as their experience in scholarly writing and research. The preliminary qualifiers included current teaching in secondary level technology education programs, a minimum of three years teaching in that area, prior curriculum development experience, creativity and innovation in technology education, technical competence, and active participation in state and national professional associations.

In an investigation of biotechnology competencies that first year or initially certified technology education teachers should acquire, Scott, Washer, and Wright (2006) selected their study participants based on a myriad of criteria. To begin, potential participants were identified and recommended by professional colleagues and educators in biotechnology. They were also chosen based upon input from the International Technology Education Association (ITEA) and the Council on Technology and Teacher Education organizations, as well as a call for participation from the ITEA's online listserv. After aggregating an initial potential participant list, expert panel members were selected. Their qualifiers for selection of

the expert panel included a demonstrated interest in the field of biotechnology, past experience in the general practice of biotechnology, and recommendations from their colleagues.

Based on the recommendation of Delbacq et al., (1975), concerning the criteria by which expert panelist will be selected, reviewing participant selection from past Delphi studies, and having identified the goals of this study, it is necessary to select Delphi participants that have the ability to identify and recommend critical attributes for developing modeling courses for online environments. Therefore, the process of selecting review and expert panelists began with recommendations from colleagues in the areas under study. Those asked to make recommendations were instructed to consider the following: knowledge of content, ability to contribute meaningful information and understand a variety of viewpoints, and lastly, provide responses to the study in a timely fashion (Finch & Crunkilton, 1999).

Representatives from the Engineering, Design, and Graphics Division of the American Society of Engineering Education, a nationally recognized organization that represents the most current collection of information, standards, and practices, and the American Drafting (Digital) Design Association, were contacted. A listserv containing active members from both organizations was requested. Upon receipt of the list-serve, an all call for participation was employed to rally panelists for both the expert and review panel. A total of 32 participants were selected for participation based on the criteria outlined below.

Before participating in this study, potential participants had a predetermined set of qualifications that had to be met in order to be selected for either panel. To be eligible for

selection, panelists met the following qualifications: Bachelor of Science or Arts from a nationally accredited university or college, current (or past) experience teaching, developing, or implementing engineering graphics courses, two or more years of participation with a professional organization in their respected area of study, and experience developing or teaching modeling or other related engineering graphics courses for online or hybrid instruction. These qualifications were selected in accordance with the guidelines for defining an expert for a panel as indicated by Delbacq et al., (1975) and based on participant selections from other Delphi studies (Kramer, Walker, & Brill, 2007; Scott, Washer, & Wright, 2006).

Demographics Questionnaire For Delphi Participants

As prescribed by Kennedy (2004), the researcher should make known the specializations and qualifications for each expert and review panel member; therefore a demographics questionnaire was administered to further describe the experience and knowledge of the study participants. The questionnaire utilized the criteria set forth as described in the previous section as the basis for the selection of the Delphi panelists. The demographics questionnaire contained eight questions including the title that most accurately described their current position and their highest degree obtained as of January 1, 2009. The purpose for obtaining their working title was to delineate between their levels of employment within a university or business setting. Based on the criteria for participation, all potential participants were required to have received a Bachelor of Arts or Bachelor of Science degree from a nationally accredited university, therefore it was necessary to know the highest degree received. Potential participants were asked to list the major area for each degree obtained in

order to gain additional information about their educational background. They were also required to list any professional affiliations, which also served as one of the participation criteria. It has been deduced that individuals that are affiliated with professional organizations most often are more aware of current research and trends. This question provided such information. As it relates to course development for engineering graphics, potential participants were asked to respond in years, to four questions that included overall experience with course development for engineering graphics education and/or modeling, experience teaching hybrid or fully online courses, experience developing courses for online environments, and professional development training for online course development. Identified experience with developing course curricula or course material for modeling courses. Although these questions received differing responses, the overall purpose was to justify experience in teaching, developing, and/or facilitating engineering graphics for online delivery.

The demographics questionnaire was administered as part of Round One of the Delphi study, but separate from the Round One questionnaire. The researcher's committee, as well as the review panel for the study, approved this questionnaire before making it accessible to the expert panel. Upon approval from the review panel, the questionnaire was made available to the expert panel. The expert panel members were given two weeks to return the responses.

INSTRUMENT DESIGN AND IMPLEMENTATION

This study was conducted utilizing a three round web-based Delphi methodology. The first phase provided opportunity for expert panelist to explore the topic under study and

contribute additional topics or information they deemed appropriate or worthy of inclusion for this investigation (Powell, 2003; Loo, 2002).

In order to examine such, panelists reviewed two areas that were the bases of the research questions. The two areas under investigation for this study were online modeling components and course design including instructional technology implementation. During the second phase of the study, expert panel members looked more critically at the results from the first phase in order to gain more comprehensive and in-depth knowledge of group perception and views. During this phase the panel of experts rated the categories and topics under study to determine those that were most important for the development of courses (Skulmoski, Hartman, & Krahn, 2007; Wicklein, 1993). During this phase components were collated and analyzed to determine a level of consensus and identify the overarching categories required to adequately answer the research questions. The items that did not reach consensus were eliminated from the final phase of the Delphi (Skulmoski, Hartman, & Krahn, 2007; Colton & Hatcher, 2004; Wicklein, 1993).

Round 1

After determining the Delphi panel based on the criteria previously mentioned in the selection of participants section of chapter three of the research methodology, and upon approval of the Round One questionnaire from the review panel, the link for the first round of questions was emailed to the expert panel for response. This questionnaire consisted of a set of instructions, categories, and open-ended questions about instructional design, drawing and modeling principles, and technology (instructional) requirements. The instrument also

contained the two research questions guiding this study as a frame of reference for the instrument components listed above.

1. What are the key elements or components necessary for designing a quality introductory modeling course for online environments?
2. What technologies are essential for the instructional design of the modeling course and implementation of the course design?

Delbacq, Van deVen, and Gustafson (1975) suggested that the first phase of a Delphi study permit participants to address the issue by writing their thoughts or ideas. They acknowledged the benefits of doing such by providing adequate time for participants to think and reflect on responses and the evasion of unwarranted focus on a particular idea. Other benefits included the prevention of opposition, rank or position pressures, and conformity issues, the ability to remain problem-centered, the avoidance of selecting ideas too hastily, the allowance of participants to maintain more flexibility through convenience, and anonymous communication.

Considering the recommendations set forth by Delbacq, Van deVen, and Gustafson (1975), the first instrument allowed participants to write statements they felt were appropriate and noteworthy for the study. This provided a multitude of categories and/or topics that were vital for the development of online modeling courses. It is important to note that statistical analysis was not utilized during this round, because the purpose of this round was to gain insight pertaining to the study's research questions about the ideas and views of the expert panel members. Panelists were asked to submit responses within two weeks from the date they received the questionnaire.

Once the data was collected, it was examined to identify emerging categories or new topics. These categories were collated and categorized based on the previously mentioned areas, instructional design, drawing and modeling principles, and technology requirements, and placed in the Round Two questionnaire. The review panel inspected the newly developed questionnaire for any modifications or revisions. Upon approval from the review panel, the next round of questioning began by emailing the questionnaire to the expert panel for response. This process of receiving and analyzing responses, modifying questionnaires, submitting questionnaires to the review panel, and the possible revision of questionnaires based on review panel suggestions, occurred for each subsequent round.

Round 2

Round Two of the web-based Delphi consisted of rating each item from Round One. During this round, a rating process was established to provide information on category and component feasibility and interest as mentioned by Beech (1999) during a Delphi study concerning change management in the healthcare field. Prior to Beech, however, Linstone and Turoff (2002) noted that a rating system must be established for the items under consideration to determine relative significance, interest, assurance, and achievability. Additionally, the rating scale must be carefully defined to assure that individual respondents understand the procedures and information provided in order to make distinctions among concepts. Considering this, clearly defined guidelines were established and the categories and topics were presented to the expert panel members in random order with Likert scales listed alongside.

The rationale for utilizing a Likert scale was based on its ability to provide information on the categories and components that were important, as well as those that were less preferable (Scheibe, Skutsh, & Schofer, 2002). The Likert scale ranged from one to five, with one representing those categories and components expert panelist strongly supported and five representing those that the expert panelist strongly opposed. After the completion of the Round Two questionnaire, it was emailed to the review panel for possible modification and upon approval forwarded to the expert panelist for review and response.

Upon receiving the responses, descriptive statistics were used to determine the means and standard deviations of each item based on the Likert scale values. After reviewing, analyzing, and collating more similar components, a Cronbach's Alpha analysis was carried out. The Cronbach's Alpha analysis is an internal consistency reliability technique that can be utilized to validate the reliability of a set of entities, or in this case components, rated by multiple participants (Osborne, 2008; Bland & Altman, 1997). The coefficient alpha (α) typically ranges between negative infinity and one. Therefore, a significant alpha is based on its proximity to one, which asserts that the closer the alpha value is to one, the greater the internal consistency (Gliem & Gliem, 2003; Graham et al., 2003). This also signifies consensus or agreement amongst participants or expert panelists (Graham et al., 2003).

Based on the research of Garson (2011), Bland and Altman (1997), and Nunnally and Bernstein (1994), when determining which components to extract for deletion an acceptable alpha value is .70. Although .70 is most often considered adequate, the context in which the alpha is being reviewed is the true determinant. George and Mallery (2003) provided the following as the major identifiers for alpha values: a value greater than .90 is excellent, a

value greater than .80, but less than .90 is good, a value greater than .70, but less than .80 is acceptable, a value greater than .60, but less than .70 is questionable, a value greater than .50, but less than .60 is poor, and lastly any value less than .50 is unacceptable.

Considering the major identifiers for alpha values, as prescribed by George and Mallery (2003), it is important to note that if the alpha for the original set of components is not equal to .70, a stepwise deletion should be performed (Field, 2005). A stepwise deletion is the removal of all items that are statistically uncorrelated to the other items in the dataset. This process, when correctly administered, requires the analysis to be performed each time an item is removed from the dataset (Walmsley et al., 2009; Field, 2005, Gliem & Gliem, 2003). For this study, individual contributions to the alpha, displayed as alpha-if-item-deleted, determined the order of the item (component) removed at each step. Once the desired alpha value of .70 was achieved, the remaining items represented a complete dataset, therefore displaying an acceptable level of internal consistency or reliability.

Based on the results from this round, the Round Three questionnaire was developed and forwarded to the review panel. The review panel examined the newly developed questionnaire for any modifications or revisions. Upon approval from the review panel, the Round Three questionnaire was made accessible and the expert panel was notified.

Round 3

The questionnaire for the final round was based on the results from the Round Two questionnaire. After approval from the review panel, expert panelists received notification of the questionnaires availability. Due to time constraints, panelists were given one week to submit responses. The expert panelists were asked to identify the components that should be

included or excluded in the inventory of best practices by denoting an acceptance or rejection.

The responses from Round Three were analyzed using the Chi-Square analysis. This test was used to compute a two-by-two contingency table. The contingency table served as representation of the null hypothesis, which suggested that for each response an option of acceptance or rejection would be present. In conjunction with each category, a calculated probability value was also computed. Components having a probability of 0.05 or less were retained and included in the final inventory of best practices. The final listing of accepted key components necessary for designing online modeling courses was developed and sent to review and expert panelist.

CHAPTER SUMMARY

This chapter provided a detailed description of the research design, including a comparison of group decision-making methods, selection of participants, and the statistical analysis utilized to obtain information about the design and development of online modeling courses for engineering graphics education. There was limited information about developing such courses specific to the field of engineering graphics education, therefore a need to establish an inventory of best practices for designing these types of courses required contribution from individuals with specialized knowledge about this issue. In order to obtain such knowledge and foresight, the Delphi method was selected based on its three main characteristics; anonymity, iteration and controlled feedback, and statistical response. It was these characteristics that were necessary to gain consensus from a group of geographically dispersed individuals with varying levels of expertise and experience.

In order to collect the necessary information pertaining to the research questions guiding this study, contributions from many individuals in the field of engineering graphics education were needed. To reach the desired outcome of consensus, as well as contribute to the growing body of literature for the field of engineering graphics education, characteristics inherent with utilizing the Delphi method - anonymity, iteration and controlled feedback, and statistical response - was the rationale for using this group decision-making method for this study.

The next chapter contains a more thorough and comprehensive explanation of the statistical data collected during each round of the Delphi study. The results of the data analysis presented in the next chapter, appear in chapter five in the form of conclusions, implications, and recommendations.

CHAPTER 4: RESEARCH FINDINGS

INTRODUCTION

This study investigated the delineation of online course development criteria for three-dimensional modeling curricula taught as a hybrid or fully online course. Due to the instructional complexity of three-dimensional modeling, few have sought to develop this type of course for online teaching and learning. This study aimed to collectively aggregate information in order to analyze and extract meaningful criteria. It's inquisition focused on the use of appropriate instructional technologies, instructional design pedagogy, aesthetics and functionality, interactive technologies, and assessment. Each of these areas directly impact course design, implementation, student response, and retention, in online environments.

The problem this study identified was that engineering graphics educators are faced with a dilemma when developing 3D modeling courses for online instruction. Because a vast array of instructional methodologies and technological tools exist, many engineering graphics educators are uncertain about which of these are most appropriate for selection and utilization in course design. The research questions guiding this study include:

1. What are the key components necessary for designing a quality introductory modeling course for online environments?
2. What technologies are essential for the instructional design of the 3D modeling course and implementation of the course design?

The results of this survey-based research study provided an inventory of best practices that would serve as an instructional blueprint for educators seeking to develop a quality three-dimensional modeling or comparable engineering graphics course taught as a

hybrid or fully online course. To triangulate and draw consensus on specific research categories and components, a web-based modified Delphi methodology was administered. The data presented in this chapter was aggregated from each round of the Delphi, as well as the Demographic Questionnaire (See Appendix B).

In order to choose the participants with the best fit for the expert and review panels, responses from the Demographics Questionnaire were analyzed and used for selection. The responses gave detailed information pertaining to the backgrounds and experiences of the participants. Following the Demographics Questionnaire each round of questions were submitted to the review panel to ensure accessibility and clarity, and to evaluate the format of the survey instruments. After approval from the review panel, each questionnaire was made accessible to the expert panel for response. As the expert panel reviewed each round, consensus on the categories and components for developing an introductory 3D modeling course for online teaching and learning began to form. This was made evident through the Delphi process and the statistical analysis of each round.

DEMOGRAPHICS OF DELPHI PANELISTS

Based on the procedures described in Chapter 3 of this research study (See Appendix B for correspondence), two panels - a review panel and an expert panel were selected. Fifty-two candidates responded to the Demographics Questionnaire, in which 62% (N=32) of the individuals qualified and were selected for participation. From the qualified pool of 32 experts, three individuals were randomly selected for the review panel. While the expert panel was responsible for submitting responses to each of the Delphi questionnaires, participation as a reviewer held the responsibility of examining the clarity, format, and

accessibility of each questionnaire developed, therefore eliminating any bias that could possibly be displayed from the researcher.

The review panel was comprised of two engineering graphics educators and one career and technical educator. Based on the criteria for participation, each member of the review panel held a Bachelor of Arts or Science degree, two or more years of service with a professional organization, experience teaching 3D modeling or related engineering graphics courses fully online or as hybrid instruction, and currently (or past experience) teaching, developing, or implementing engineering graphics courses.

Participation in this study as an expert panel member was equivalent to that of a review panelist. The expert panel consisted of 29 participants in academia and industry, representing various areas of engineering graphics education. As indicated by the demographic results reported by the expert panel (Table 5), the majority (n=11) of the participants were engineering graphics educators, followed by engineering educators (n=8), and technology educators (n=7). Three expert panel participants reported 'other' as their position title. They listed their current titles on the Demographics Questionnaire as Associate Dean of Technology, Director of Training and Workforce Development, and Occupational Safety and Health educator.

As indicated in the criteria for participation, all participants must have obtained a Bachelor of Science or Arts from an accredited college or university. All qualified participants reported having obtained a Bachelors degree. Fifty-two percent (n=15) of the expert panelists reported a Master of Science/Education degree as the highest degree obtained, with three expert panel members currently working toward a doctoral degree.

Forty-five percent (n=13) of the expert panelist listed a Doctorate of Education/Philosophy as the highest degree obtained.

Additional criteria included two or more years of professional membership associations, of which all twenty-nine expert panel participants reported active involvement, and current (or past) experience teaching, developing, or implementing engineering graphics courses. Eighty-six percent (n=25) of the expert panelists indicated current teaching or development experience, while 14% (n=4) denoted previous 'hands-on' experience working with 3D modeling courses.

Course development experiences for fully online teaching and development, or for hybrid instruction, displayed the majority of the expert panelists (n=11) as having two to three years of overall experience. Several expert panel members (n=8) indicated three or more years of course development experience, and seven panelists listed two years or less. Three expert panel members did not respond.

When looking more closely at course development experiences for online environments, including revising traditional courses for online teaching or creating novel courses, expert panel members reported utilizing a combination of tools. These tools included Learning Management Systems to distribute course content, lecture capture software to create and deliver video content, screencasts for capturing software demonstrations, electronic grading for quizzes and tests, and synchronous sessions to enhance interactivity amongst the course facilitator and students. Expert panelists also identified several challenges to consider. These challenges included network speed, which is critical to the success of launching and running software applications that rely heavily on the creation and utilization

of graphic imagery, the submission and grading of graphics assignments and three-dimensional models, and Internet speed and bandwidth for delivering online materials to those in developing countries.

Although the expert panelist reported their overall course development experience, it was also necessary for them to provide information about teaching and developing specifically for fully online and hybrid instruction. Of the 29 expert panel members, 52% (n=15) did not have experiences with teaching or developing fully online 3D modeling or comparable engineering graphics courses. Twenty-eight percent (n=8), however, taught or developed courses for three or more years, 6% (n=2) reported two to three years, and 14% (n=4) indicated experiences of two years or less. For hybrid instruction, 48% (n=14) listed three or more years of experience, and 45% (n=13) selected two years of experience or less. Additionally, two expert panel members (7%) reported having no experience with developing for hybrid instruction. They did however, indicate experiences with developing for fully online teaching, and/or were currently developing a hybrid engineering graphics course.

Table 5

Demographic Information for Expert Panel

Description	Number	Percentage
Title/Position		
Engineering Educator	8	28%
Engineering Graphics Educator	11	38%
Technology Educator	7	24%
Other	3	10%
Total	29	100%
Highest Degree Obtained		
Bachelors Degree	1	3%
Masters Degree	15	52%
Doctoral Degree	13	45%
Total	29	100%
Professional Memberships		
2 or more years	29	100%
Status		
Currently teaching, developing, or implementing engineering graphics courses	25	86%
Past experience teaching, developing or implementing engineering graphics courses	4	14%
Total	29	100%

Table 5 (continued)

Description	Number	Percentage
Course Development (in years)		
3 or more	8	28%
2-3 years	11	38%
2 years or less	7	24%
No Response	3	10%
Total	29	100%
Fully Online Teaching/Development (in years)		
3 or more	8	28%
2-3 years	2	6%
2 years or less	4	14%
None	15	52%
Total	29	100%
Hybrid Online Teaching/Development (in years)		
3 or more	14	48%
2-3 years	0	0%
2 years or less	13	45%
None	2	7%
Total	29	100%

DELPHI STUDY DATA

Round 1 of the Modified Delphi Study

After receiving approval of the Round One questionnaire from the review panel, expert panel participants were notified of its availability. The questionnaire was comprised of nine categories, eighteen components, and text fields for additional responses (See Appendix C for correspondence). The elements that should be considered when developing courses for online or hybrid instruction were derived from the literature review. Those elements were included in the Round One questionnaire. Topics ranged from instructional/course design to drawing and modeling content.

During this round, expert panel members were asked to keep, reject, or modify the provided categories and components, and provide any additional information to be considered in the subsequent round. Twenty-nine individuals were listed as expert panelists; however, only 55% (n=16) of the participants completed and submitted the Round One questionnaire. Although this percentage is much lower than was expected, the lack of participation from the expert panelists could possibly be based on time constraints and prior commitments. Table 6 outlines the expert panel responses to the categories and components from Round One.

Table 6

Round 1 Categories & Components to Keep, Reject, or Modify

Initial Categories & Components	Keep	Reject	Modify	No Res
<i>The Adult Learner</i>	12	3	1	0
Students enrolled in an online 3D Modeling course should take the initiative to acquire and construct new knowledge.	12	0	4	0
Students enrolled in an online 3D modeling course should establish individual learning goals for online learning.	9	3	4	0
<i>Learner-Centered Framework</i>	13	1	1	1
Learner-centered framework is based on two ideas-the individual and the learning.	12	1	2	1
In an online 3D modeling course, individual learner experiences should be valued.	12	2	1	1
<i>Knowledge-Centered Framework</i>	15	0	1	0
The construction of new knowledge structures in an online 3D modeling course is essential to its success.	10	3	3	0
Students enrolled in an online 3D modeling course should find meaning and relevance in their coursework.	13	2	1	0

Note: Total number of responses for each category and component is sixteen.

Table 6 (continued)

Initial Categories & Components	Keep	Reject	Modify	No Res
<i>Community-Centered Framework</i>	12	4	0	0
Establishing communities of practice through course activities is essential in an online 3D modeling course.	10	2	4	0
3D modeling courses taught online should promote creative and critical thinking whether independently or collaboratively.	14	1	1	0
<i>Assessment-Centered Framework</i>	15	0	1	0
In an introductory 3D modeling course, assessments should be considered as part of the instructional process and be used to adjust teaching practices while instruction is taking place.	12	1	3	0
In an online introductory 3D modeling course, assessments should act as an accountability measurement and be given periodically in the form of quizzes tests.	12	1	3	0
<i>Instructional Design for 3D Modeling</i>	15	0	1	0
3D modeling content delivered online is developed from course objectives and utilizes appropriate instructional technologies.	14	0	2	0
3D modeling courses taught online should continue to use offline sketching activities.	15	0	1	0

Note: Total number of responses for each category and component is sixteen.

Table 6 (continued)

Initial Categories & Components	Keep	Reject	Modify	No Res
<i>Drawing & Modeling Content</i>	15	0	1	0
Online 3D modeling courses should include 3D visualization and modeling techniques.	14	0	2	0
Online 3D modeling courses should provide instruction on traditional topics such as dimensioning.	12	1	3	0
<i>Identifying Interactions</i>	12	3	1	0
Interactions should allow learners to interface with the environment in which the learning takes place.	10	3	2	1
Learners interactions in online 3D modeling courses include interactions with a Learning Management System, content via the web, or Web 2.0 technologies.	10	4	1	1
<i>Interactive Technologies</i>	15	0	1	0
Online 3D modeling courses should use application sharing through synchronous communications to demonstrate design software's such as SolidWorks.	13	0	3	0
3D modeling courses taught online should use demonstrations videos and voice-over PowerPoints.	13	0	3	0

Note: Total number of responses for each category and component is sixteen.

During this round participants were permitted to suggest modifications to categories and/or components. Although expert panelists did not provide any revisions for the categories presented in this round, 78% (n=14) of the components elicited phrasing revisions. Table 7 displays the modifications provided by the expert panel.

Table 7

Revised Categories & Components for Round 2

Initial Category or Component	Revised Category or Component
Students enrolled in an online 3D modeling course should take the initiative to acquire and construct new knowledge.	Students enrolled in an online 3D modeling course should take the initiative to acquire knowledge through identifying, selecting, or constructing a learning pathway from a series of predefined modules guided by the instructor.
Students enrolled in an online 3D modeling course should establish individual learning goals for online learning.	Students enrolled in an online 3D modeling course should have an understanding of course standards and objectives in order to establish individual learning goals that are aligned with the course.
Learner-centered framework is based on two ideas-the individual and the learning.	Online 3D modeling courses should be based on the idea that the learner will be actively engaged in the learning process.
The construction of new knowledge structures in a 3D online modeling course is essential to its success.	The construction of new knowledge structures is important in an online 3D modeling course.
Students enrolled in an online 3D modeling course should find meaning and relevance in their coursework.	Students enrolled in an online 3D modeling course should understand, and find meaning and relevance in the application of their coursework.

Table 7 (continued)

Initial Category or Component	Revised Category or Component
Establishing communities of practice through course activities is essential in an online 3D modeling course.	Ensuring sufficient participation through course activities, group discussions, and collaborative projects establishes a sense of community and is essential in an online 3D modeling course.
In an introductory 3D modeling course, assessments should be considered as part of the instructional process and be used to adjust teaching practices while instruction is taking place.	In an online introductory 3D modeling course, assessments should serve as an accountability measurement and be given periodically in the form in which the learning has been obtained.
In an online introductory 3D modeling course, assessments should act as an accountability measurement and be given periodically in the form of quizzes tests.	In an online introductory 3D modeling course, assessments should serve as an accountability measurement and be given periodically in the form in which the learning has been obtained.
3D modeling content delivered online is developed from course objectives and utilizes appropriate instructional technologies.	3D modeling content delivered online is derived from course objectives and competencies.
Online 3D modeling courses should include 3D visualization and modeling.	Visualization for 3D models should be taught in an online 3D modeling course.
Online 3D modeling courses should provide instruction on traditional topics such as dimensioning.	The scope and context of 3D models in a modeling course should determine if traditional topics such as dimensioning will be taught.
Interactions should allow learners to interface with the environment in which the learning takes place.	Interactions in the environment where learning takes place is important when solving real world issues.

Table 7 (continued)

Initial Category or Component	Revised Category or Component
3D modeling courses should use application sharing through synchronous communications to demonstrate design software's such as SolidWorks.	Application sharing should be used to demonstrate design software.
3D modeling courses taught online should use demonstration videos and voice-over PowerPoints.	3D modeling courses taught online should use demonstration videos and voice-over PowerPoints as an instructional option.

The Round One questionnaire also provided editable text fields for expert panelists to type additional comments, suggestions, and/or components they believed should be considered for the Round Two questionnaire. Expert panel members suggested 27 new components to be included for review in the subsequent round. The new components are listed in Table 8.

Table 8

New Components Suggested for Round 2

Category	Suggested New Components
The Adult Learner	<p>The prior knowledge of students enrolled in an online 3D modeling course is impacted by work and life obligations.</p> <p>Students need to be self motivated and disciplined when taking 3D modeling online courses.</p>

Table 8 (continued)

Category	Suggested New Components
Community-Centered Instructional Framework	3D modeling courses taught online should promote community-constructed knowledge.
Assessment-Centered Instructional Framework	In an online 3D modeling course, assessments should be developed from project-based learning. In an online 3D modeling course, formative assessments that provide specific guidance to correct errors should be context dependent and should be used to provide periodic feedback to learners
Instructional Design	3D modeling courses taught online should have a clear feedback path established that allows students to communicate with the instructor/professor. Instructional design for 3D modeling courses should include collaborative project work for small teams/groups. The 3D modeling online course should be interactive and capable of being tailored to the user. Online 3D modeling courses should provide adequate links, readings, and online discussions.
Drawing & Modeling Content	Process flows should be taught in an online 3D modeling course. The modeling thought process should be included in instruction for online 3D modeling courses.

Table 8 (continued)

Category	Suggested New Components
Drawing & Modeling Content (continued)	<p data-bbox="846 346 1422 451">Drawing and modeling content for online 3D modeling courses should include geometry constructions and relationships.</p> <p data-bbox="846 493 1422 640">3D modeling courses taught online should demonstrate the application of 3D modeling in practical applications of design and manufacturing.</p> <p data-bbox="846 682 1422 745">Online 3D modeling courses should include modeling theory and strategies.</p> <p data-bbox="846 787 1422 850">Online 3D modeling courses should demonstrate software specific techniques.</p> <p data-bbox="846 892 1422 1113">Online 3D modeling courses should provide instruction about the different types of 3D modeling (parametric modeling, constraint based modeling, boundary representation and wireframe/surface modeling, and constructive solid geometry modeling).</p> <p data-bbox="846 1155 1422 1333">Online 3D modeling courses should introduce geometric dimensioning and tolerancing to teach the concepts of using physical features for datums and bonus tolerance.</p> <p data-bbox="846 1375 1422 1480">3D modeling courses taught online should provide instruction on troubleshooting and correcting common modeling errors.</p> <p data-bbox="846 1522 1422 1623">3D modeling courses taught online should provide historical information and new directions for the 3D modeling industry.</p>

Table 8 (continued)

Category	Suggested New Components
Identifying Interactions	<p>3D modeling concepts should include real world problem solving related to codes and standards, strength of materials, and common manufacturing practices.</p> <p>CAD programs containing specific design components or "tool boxes" should be clearly identified and explained in online instruction.</p> <p>Drawing standards should be included in online 3D modeling courses.</p> <p>Instruction on multiviews and isometric assembly views-manually and using software-should be included in online instruction.</p> <p>Learning interactions in online 3D modeling courses should include peer-to-peer interactions.</p> <p>Learning interactions in online 3D modeling courses should include communications with the course professor and other instructors.</p> <p>Collaborative discussions and demonstrations amongst class members and/or assigned groups should be utilized for self-teaching amongst peers.</p>
Interactive Technologies	<p>3D modeling courses taught online should include interactive exercises that react to student input and provide constructive, context-sensitive feedback to the student.</p>

Round 2 of the Modified Delphi Study

After all data collected in Round One was tabulated and organized, the Round Two questionnaire was developed. The new questionnaire was sent to the review panel for examination. After receiving approval from the review panel, the expert panel was notified and access to the questionnaire was provided. In this round, the expert panelists were asked to rate each category and component listed on the Round Two questionnaire (See Appendix D for correspondence). The content presented in this questionnaire reflected the information submitted by the expert panel from Round One. The Round Two questionnaire contained the initial nine categories, four original components, fourteen modified components, and twenty-seven new components.

In order to rate the content of this questionnaire, the panel of experts utilized a Likert Scale ranging from one to five. This scale was used to represent their agreement or opposition to the consideration/inclusion of the components listed in the questionnaire for the inventory of best practices. Likert Scale classifications were as follows: strongly agree, agree, neutral, disagree, and strongly disagree. Although modifications were no longer required for each category or component presented in this questionnaire, expert panelists were provided an editable text field for the insertion of comments or suggestions, or to input additional components they believed should be included in the Round Three questionnaire.

After collecting all data for this round, the statistical means and standard deviations (Appendix D, Table A) were calculated from the responses for each component. Although this data was not used to determine the categories or components that would progress to the next round, it was useful in understanding the collective position of the participants. This

round yielded a 41% (n=12) response rate based on the total number of participants (29) and a 75% return rate from those that participated in Round One.

Cronbach's Alpha

In order to determine the components that would remain for Round Three, the statistical analysis Cronbach's Alpha was employed. Based on the procedures for calculating Cronbach's Alpha in tandem with the literature regarding the grouping of the subject matter used in each category overall, several categories were combined and renamed to meet the criteria. The renamed categories for this round were *Learner-Centeredness* and *Course Design*. Components for the category *Learner-Centeredness* were derived from *The Adult Learner* category (components 1-4), the *Learner-Centered Instructional Framework* category (components 6-7), and the *Knowledge-Centered Instructional Framework* category (components 9-10). The category *Course Design* included components from the previous *Community-Centered Instructional Framework* (components 12-14), *Assessment-Centered Instructional Framework* (components 16-19), *Instructional Design* (components 21-27), *Identifying Interactions* (components 46-50), and *Interactive Technologies* (components 52-53). All component numbers aligned with the Round Two questionnaire. The category *Drawing and Modeling Content* remained the same. From the Cronbach's Alpha analysis, five components were eliminated from further consideration. The remaining items would serve as components for the Round Three questionnaire.

Cronbach's Alpha - Results for Learner-Centeredness

The first set of data to be analyzed utilizing the Cronbach's Alpha analysis was the renamed category *Learner-Centeredness*. This category was initially comprised of eight

items yielding a reliability coefficient alpha of .601 and a categorical mean of 13.58 (Appendix D, Table B). As prescribed by Garson (2011), Field (2005), and George and Mallery (2003), an acceptable alpha is .70. In order to achieve an acceptable alpha ($\alpha = 0.70$) for retaining items to be used for the next round, components must be individually eliminated from the listing using stepwise deletion. When determining the first component to remove in order to reach the desired alpha of .70, the component offering the greatest contribution to the alpha should be eliminated first.

Stepwise Deletion 1 - Removing Component 9

As indicated by the initial results (Appendix D, Table B), the first component if removed, that had the greatest effect toward increasing the alpha using stepwise deletion was component nine. Removing component nine would increase the alpha from .601 to .672 (Appendix D, Table C). Considering this, component nine was the first component removed from the list of items. It is also important to note that components five and eight were not included in the analysis. Both components were text fields in the Round Two questionnaire, therefore not collecting any numerical entries. It is also important to note, that as components were removed, the mean, variance, and standard deviation values were decreased. The reduction of these values indicated that the remaining components remaining in the list of items were more greatly correlated.

Stepwise Deletion 2 - Removing Component 3

The removal of component nine also altered the remaining 'alpha if item deleted' statistics for each component. This information was used to determine which component would be eliminated in the second stepwise deletion. After removing component nine,

component three now offered the highest change in the alpha if deleted. The removal of component three would increase the alpha from .672 to .696 (Appendix D, Table D). Given this, component three was eradicated from the list of items in the second stepwise deletion, and would not be included in the analysis with the remaining components. Components five and eight were not included in this stepwise deletion. In the Round Two questionnaire they were editable text fields, therefore not yielding any numerical values. This analysis was also conducted without component nine, because it was eliminated in the first stepwise deletion.

Stepwise Deletion 3 - Removing Component 6

With six components remaining, the total mean was 9.67 and the variance 5.697. After the removal of component three ($\alpha=.696$), it was clear that component six would be the final component required for deletion. The removal of component six increased the alpha from .696 to .721, raising the alpha beyond the desired value of .70. The results from removing component six can be found in Table 9. As previously stated, components five and eight were not included in this analysis. In the Round Two questionnaire they were editable text fields, therefore not yielding any numerical values. This analysis was also conducted without component nine because it was eliminated in the first stepwise deletion, and component six because it was removed in the second stepwise deletion.

As indicated by the results, as the reliability coefficient alpha increased, progressing closer to one, the mean, variance, and standard deviation decreased. Again, it is important to note this, because a decrease in these values, especially variance, signified that the remaining components had less variability amongst them. This implied that as seemingly dissimilar

components were removed, those retained had greater commonality amongst one another, resulting in a more cohesive list of items.

With the removal of three components (3, 6, 9), the category *Learner-Centeredness* was now comprised of five components, (1, 2, 4, 7, 10), and were included in the Round Three questionnaire. Table 9 values display the output after the removal of component six. It also serves as the final results for the remaining components

Table 9

Final Results for Learner-Centeredness

	N	Mean	Variance	SD
Scale Statistics	5	8.42	5.174	2.275
Reliability Coefficient	$\alpha = 0.721$			
<hr/>				
Item-Total Statistics	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C1	6.33	2.242	.787	.514
C2	6.67	3.333	.462	.685
C3	Eliminated 2 nd	--	--	--

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C5 & C8 were not included in analysis. They were text fields in the Round 2 questionnaire.

Note: C9 was not included in this analysis. It was eliminated in the first stepwise deletion.

Note: C3 was not included in this analysis. It was eliminated in the second stepwise deletion.

Note: C6 was not included in this analysis. It was eliminated in the third stepwise deletion.

Table 9 (continued)

C4	7.17	4.152	.444	.696
C6	Eliminated 3 rd	--	--	--
C7	6.58	4.083	.325	.727
C9	Eliminated 1 st	--	--	--
C10	3.902	3.902	.485	.678

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C5 & C8 were not included in analysis. They were text fields in the Round 2 questionnaire.

Note: C9 was not included in this analysis. It was eliminated in the first stepwise deletion.

Note: C3 was not included in this analysis. It was eliminated in the second stepwise deletion.

Note: C6 was not included in this analysis. It was eliminated in the third stepwise deletion.

Cronbach's Alpha - Results for Course Design

As previously discussed in the *Cronbach's Alpha* section of this study, several categories and components from the original study were combined to meet the criteria for conducting a Cronbach's Alpha analysis. Given this, the order in which the components appear in the tables below exclude component numbers that would normally appear chronologically. Although the components are represented in this manner, they continue to align with the number identifiers on the Round Two questionnaire.

For the second dataset, Cronbach's Alpha was also employed to analyze the data for the category *Course Design*. This category was comprised of 38% (n=21) of the total components for the Round Three questionnaire. The reliability statistics for this category

displayed an original reliability coefficient alpha of .878 and a total mean of 79.42. Alpha values for the group of components ranged from .861 to .879, all well above the targeted value ($\alpha=0.70$). A high overall and individual alpha signified greater internal consistency reliability amongst the components, meaning less variability amongst the components in the list. Because the overall alpha value was significantly greater than the targeted value of .70, a stepwise deletion was not required. *Course Design* data results are listed in Table 10.

Table 10

Final Results for Course Design

	N	Mean	Variance	SD
Scale Statistics	21	39.42	75.538	8.691
Reliability Coefficient	$\alpha = 0.878$			
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C12	37.42	66.447	.388	.879
C13	37.67	69.879	.507	.872
C14	37.00	66.727	.544	.870
C16	37.92	68.083	.518	.871
C17	37.67	67.879	.571	.869
C18	37.42	74.629	.028	.886

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Table 10 (continued)

Item-Total Statistics	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C19	37.75	69.295	.435	.874
C21	38.17	72.515	.366	.876
C22	37.75	69.295	.435	.874
C23	37.33	64.606	.808	.861
C24	38.08	71.174	.496	.873
C25	37.17	64.333	.596	.868
C26	37.08	66.083	.601	.868
C27	37.75	73.114	.259	.878
C46	37.33	69.152	.534	.871
C47	36.92	67.902	.457	.873
C48	37.50	69.182	.531	.871
C49	38.17	72.152	.414	.875
C50	37.25	68.750	.674	.868
C52	37.25	68.932	.426	.874
C53	37.75	67.477	.583	.869

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Cronbach's Alpha - Results for Drawing & Modeling Content

The final category to be analyzed utilizing the Cronbach's Alpha analysis was *Drawing and Modeling Content*. The category was initially comprised of sixteen components however, after conducting the analysis fourteen components remained. The fourteen components represented 25% of the total components for the Round Three questionnaire. After examining expert responses, the data resulted in an initial alpha of .648 with a total mean of 35.00. Because the alpha was not the desirable value of .70, a stepwise deletion was required. Appendix D outlines the results of the data before the elimination of any components.

Stepwise Deletion 1 - Removing Component 33

After reviewing the initial data, as shown in Table E (Appendix D), the component indicating the most significant increase toward reaching the desired alpha ($\alpha=.70$) if removed, was component 33. The data indicated that the removal of component 33 would increase the alpha from .648 to .683. Component 33 was therefore, the first component in this category to be eliminated because it offered the greatest contribution toward achieving an alpha of .70. The remaining 'alpha if item deleted' for the components now ranged from .625 to .705 (Appendix D, Table F).

Stepwise Deletion 2 - Removing Component 30

With component 33 eliminated, the data denoted that reaching an alpha of .70 or greater, would be achieved by removing component 30 as well. As shown in Table F (Appendix D), the removal of component 30 would yield an alpha of .705, increasing it from

.683. Component 30 was therefore eliminated, and all other drawing and modeling content components were retained for Round Three. The results from removing component 30 are outlined in Table 11 and are the final results for this category.

Table 11

Final Results for Drawing & Modeling Content

	N	Mean	Variance	SD
Scale Statistics	14	30.17	26.697	5.167
Reliability Coefficient	$\alpha = 0.705$			
<hr/>				
Item-Total Statistics	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C29	28.67	22.606	.567	.663
C30	Eliminated 2 nd	--	--	--
C31	27.67	24.242	.231	.699
C32	28.67	23.879	.359	.685
C33	Eliminated 1 st	--	--	--
C34	28.17	21.970	.371	.682
C35	28.83	26.697	-.048	.719

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C33 was not included in this analysis. It was eliminated in the first stepwise deletion.

Note: C30 was not included in this analysis. It was eliminated in the second stepwise deletion.

Table 11 (continued)

C36	28.00	25.636	.231	.700
C37	28.33	23.152	.296	.693
C38	27.33	23.515	.253	.699
C39	28.42	24.629	.273	.694
C40	27.25	24.932	.292	.694
C41	27.67	25.515	.107	.711
C42	27.67	21.697	.587	.654
C43	27.83	22.333	.365	.683
C44	27.67	18.788	.543	.651

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C33 was not included in this analysis. It was eliminated in the first stepwise deletion.

Note: C30 was not included in this analysis. It was eliminated in the second stepwise deletion.

Additional & Revised Components

As previously stated, expert panel members were not required to submit modifications for categories or components during Round Two. Based on the procedures set forth for this study however, an editable text field was provided for comments, suggestions, or additional components to be added or reviewed for the Round Three questionnaire. Several recommendations for improving the phrasing of components were submitted by the expert panel participants. Of the forty-four original components of the Round Two

questionnaire, only 21% (n=9) had suggested revisions to phrasing. Table 12 reflects the modifications for those components.

Table 12

Revised Components for Round 3

Round 2 Component	Revised Components
Information constructed from the community of learners should be promoted and included in instruction or serve as supplemental material for online modeling courses.	Information constructed from the community of learners (course participants) should be promoted and included in instruction or serve as supplemental material for online modeling courses.
Assessments should serve as an accountability measurement should periodically be given in the form in which the learning has been obtained.	Assessments should periodically be given in the form in which the learning has been obtained.
In an online 3D modeling course, assessments should be developed from project-based learning.	Assessments should be developed from all course activities including project-based learning activities.
3D modeling courses taught online should use demonstration videos and voice-over PowerPoints as an instructional option.	Content delivered asynchronously should include multiple methods of delivery to meet individual learning styles.
Instructional design for 3D modeling courses should include collaborative project work for small teams/groups.	Online modeling courses should support and provide collaborative project work for small teams/groups.
The 3D modeling online course should be interactive and capable of being tailored to the user.	The online 3D modeling environment should provide students with the capability of tailoring or customizing their learning experience.

Table 12 (continued)

Round 2 Component	Revised Components
Online 3D modeling courses should provide adequate links, readings, and online discussions.	Adequate internal and external links, course readings, and engaging discussions should be included in online learning.
Application sharing should be used to demonstrate design software.	Application sharing should be used for live demonstrations of course software.
3D modeling courses should include modeling theory and strategies.	Modeling theory and strategies should be included in online instruction.

In addition to minor modifications of existing components, 15 new components to be included and voted upon in Round Three were also submitted. Table 13 illustrates the new components, which were added to the Round Three questionnaire for final consideration upon approval from the review panel.

Table 13

Additional Components to be Included in Round 3

Online modeling courses should employ collaborative tools such as wikis to allow learners to discuss, construct, or demonstrate understanding of course topics.

Online modeling courses should utilize discussion boards to pose thoughts/questions, evoke responses, and/or address issues.

Online interactive whiteboards should be used in online modeling courses to facilitate real-time collaborations between learners or between the course instructor and the learners.

Table 13 (continued)

Blogs should be included in online modeling courses to document processes, share opinions, provide commentary, and/or personal reflections about course projects, assignments, or questions posed by the instructor.

Live (real-time, synchronous) tools should occasionally be included in online modeling courses to facilitate course presentations, communications, and/or establish a greater sense of personal engagement between the learners and the course instructor.

Social bookmarking tools should be utilized to collectively identify and construct an inventory of online modeling resources/websites.

Online interactions include accessing content through a course website.

Application sharing should be utilized to assess the student's knowledge of software application.

Real-time applications for the creation of process flows and diagrams should be included in online instruction.

Modeling content delivered asynchronously should include lecture capture videos.

Course content should be displayed using voice-over PowerPoints.

Demonstration videos displaying hands-on sketching practices/techniques should be included in online instruction.

Screencasts should be included in online modeling content to visually present recorded step-by-step processes/demonstrations of course software usage.

Online modeling courses should incorporate simulations/animations to demonstrate the internal processes of model building.

Podcasts should be used to provide audible explanations, commentary, and/or reflections on course assignments, course projects, and/or overall student progress.

Round 3 of the Modified Delphi Study

Round 3, the final round of this Delphi study was employed to determine the final consensus for components to be considered or included in an inventory of best practices. This questionnaire totaled 66 questions, 11 of which were demographic questions taken from the Demographics Questionnaire. Due to the time span of the study, the researcher found it necessary to collect demographic information once more in case of possible changes in participant data since the start of the study. See Appendix E for Round Three Questionnaire and correspondences.

Continuing with the procedures set forth in this study, the questionnaire was approved by the review panel before access was granted to the expert panel. Expert panel members were asked to accept or reject the components listed in the questionnaire for the inventory of best practices. Modifications to components or text fields for inputting comments or additional components were not permitted during this round. Forty-five percent ($n=13$) of the total number of respondents ($N=29$) completed and submitted their responses. Although the number of participants was much less than the researcher expected, lack of time, the length of the study, and other commitments could possibly serve as the reason for this attrition. Based on participation from the previous round, however, the response rate was over 100% due to the submittal of an additional questionnaire from a respondent that did not participate in Round Two.

The data collected in this round was analyzed utilizing a Chi-Square statistical analysis. Components were placed in a contingency table to indicate the number of collected responses for the acceptance or rejection of the component. In order to determine the

components that would remain for the final inventory a probability value for each component was determined. To calculate the probability value, the Chi-Square statistic with one degree of freedom was used. Components with a probability value of less than .05 were retained for the final inventory of best practices. Table 14 outlines the results of the Chi-Square analysis.

Table 14

Chi-Square Analysis, Components Accepted or Rejected for Final Inventory of Best Practices

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
<i>Learner-Centeredness</i>					
1. Students should take the initiative to acquire knowledge through identifying, selecting, or constructing a learning pathway from a series of predefined modules guided by the instructor.	13	11 (84.6)	2 (15.4)	6.231	.05
2. Students should have an understanding of course standards and objectives in order to establish individual learning goals that are aligned with the course.	13	13 (100)	0 (0)	13.000	.001
3. Students need to be self-motivated and disciplined when taking 3D modeling courses online.	13	13 (100)	0 (0)	13.000	.001
4. Individual learner experiences should be valued and considered in online 3D modeling courses.	13	11 (91.7)	1 (8.3)	8.333	.01

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
<i>Course Design</i>					
5. Students should understand, and find and relevance in the application of their coursework.	13	12 (92.3)	1 (7.7)	9.308	.01
6. Ensuring sufficient participation through course activities, group discussions, and collaborative projects is essential in a hybrid or fully online modeling course.	13	12 (92.3)	1 (7.7)	9.308	.01
7. Online modeling courses should promote creative and critical thinking through independent and/or collaborative work.	13	12 (92.3)	1 (7.7)	9.308	.01
8. *Information constructed from the community of learners (course participants) should be promoted and included in instruction or serve as supplemental material for online modeling courses.	13	11 (84.6)	2 (15.4)	6.231	.05
9. Assessments should be considered as part of the instructional design process when developing online instruction.	13	13 (100)	(0)	13.000	.001
10. *Assessments should periodically be given in the form in which the learning has been obtained.	13	13 (100)	(0)	13.000	.001

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
11. Assessments should be developed from all course activities including project-based learning activities.	13	11 (84.6)	2 (15.4)	6.231	.05
12. Assessments that provide specific guidance to correct errors should be context dependent and used to provide periodic feedback to learners.	13	11 (91.7)	1 (8.3)	8.333	.01
13. 3D modeling content delivered online should derive from course objectives and course competencies.	13	13 (100)	0 (0)	13.000	.001
14. Sketching activities should be used as a supplement when teaching 3D modeling online.	13	11 (84.6)	2 (15.4)	6.231	.05
15. *Content delivered asynchronously should include multiple methods of delivery to meet individual learning styles.	13	10 (76.9)	3 (23.1)	3.769	.10**
16. Online modeling courses should have a clear feedback path established that allows students to communicate with the instructor/professor.	13	13 (100)	0 (0)	13.000	.001
17. *Online modeling courses should support and provide collaborative project work for small teams/groups.	13	11 (84.6)	2 (15.4)	6.231	.05

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
18. *The online 3D modeling environment should provide students with the capability of tailoring or customizing their learning experience.	13	9 (75)	3 (25)	3.000	.10**
19. *Adequate internal and external resource links, and required and supplemental readings, should be included in online modeling learning.	13	13 (100)	0 (0)	13.000	.001
20. Establishing and encouraging interactions in the online environment is important when addressing and solving real world issues related to 3D modeling.	13	13 (100)	0 (0)	13.000	.001
21. *Online interactions with course content include the use of a Learning Management System (LMS).	13	12 (92.3)	1 (7.7)	9.308	.01
22. Peer-to-peer interactions should be fostered and designed into hybrid and online instruction.	13	11 (84.6)	2 (15.4)	6.231	.05
23. Communications with the course professor and other instructors knowledgeable of the subject matter should be encouraged.	13	13 (100)	0 (0)	13.000	.001

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
24. Collaborative discussions and demonstrations amongst class members and/or assigned groups should be included and utilized for self-teaching amongst peers.	13	12 (92.3)	1 (7.7)	9.308	.01
25. *Application sharing tools should be used for live demonstrations of course software.	13	12 (92.3)	1 (7.7)	9.308	.01
26. Interactive exercises that react to student input and provide constructive, context-sensitive feedback to the student should be included in online instruction.	13	10 (83.3)	2 (16.7)	5.333	.05
27. *Online modeling courses should employ collaborative tools such as wikis to allow learners to discuss, construct, or demonstrate understanding of course topics.	13	10 (76.9)	3 (23.1)	3.769	.10**
28. *Online modeling courses should utilize discussion boards to pose thoughts/questions, evoke responses, and/or address issues.	13	12 (92.3)	1 (7.7)	9.308	.01
29. *Online interactive whiteboards should be used in online modeling courses to facilitate real-time collaborations between learners or between the course instructor and the learners.	13	10 (76.9)	3 (23.1)	3.769	.10**

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
30. *Blogs should be included in online modeling courses to document processes, share opinions, provide commentary, and/or personal reflections about course projects, assignments, or questions posed by the instructor.	13	6 (46.2)	7 (53.8)	.077	.80**
31. *Live (real-time, synchronous) tools should occasionally be included in online modeling courses to facilitate course presentations, communications, and/or establish a greater sense of personal engagement between the learners and the course instructor.	13	10 (76.9)	3 (23.1)	3.769	.10**
32. *Social bookmarking tools should be utilized to collectively identify and construct an inventory of online modeling resources/websites.	13	7 (53.8)	6 (46.2)	.077	.80**
33. Online interactions include accessing content through a course website.	13	12 (92.3)	1 (7.7)	9.308	.01
34. *Application sharing should be utilized to assess the student's knowledge of software application.	13	11 (84.6)	2 (15.4)	6.231	.05

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
35. Real-time applications for the creation of process flows and diagrams should be included in online modeling instruction.	13	9 (69.2)	4 (30.8)	1.923	.20**
36. *Modeling content delivered asynchronously should include lecture capture videos.	13	11 (84.6)	2 (15.4)	6.231	.05
37. Course content should be displayed using voice-over PowerPoints.	13	10 (76.9)	3 (23.1)	3.769	.10**
38. *Demonstration videos displaying hands-on sketching practices or techniques should be included in online instruction.	13	11 (84.6)	2 (15.4)	6.231	.05
39. *Screencasts should be included in online modeling content to visually present recorded step-by-step processes/demonstrations of course software usage.	13	11 (84.6)	2 (15.4)	6.231	.05
40. *Online modeling courses should incorporate simulations/animations to demonstrate the internal processes of model building.	13	13 (100)	0 (0)	13.000	.001

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
41. *Podcasts should be used to provide audible explanations, commentary, and/or reflections on course assignments, course projects, and/or overall student progress.	13	6 (46.2)	7 (53.8)	.818	.50**
<i>Drawing & Modeling Content</i>					
42. Visualization for 3D models should be taught in an online modeling course.	13	11 (84.6)	2 (15.4)	6.231	.05
43. Process flows should be taught in an online modeling course.	13	8 (66.7)	4 (33.3)	1.333	.30**
44. The modeling thought process should be included in online instruction.	13	13 (100)	0 (0)	13.000	.001
45. The application of 3D modeling in practical applications of design and manufacturing should be demonstrated.	13	12 (92.3)	1 (7.7)	9.308	.01
46. *Modeling theory and strategies should be included in online instruction.	13	13 (100)	0 (0)	13.000	.001

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
47. Online modeling courses should demonstrate software specific techniques.	13	10 (76.9)	3 (23.1)	3.769	.10**
48. Instruction about the different types of 3D modeling (parametric modeling, constraint based modeling, boundary representation and wireframe/surface modeling, and constructive solid geometry modeling) should be included in an online modeling course.	13	13 (100)	0 (0)	13.000	.001
49. Online 3D modeling courses should introduce geometric dimensioning and tolerancing to teach the concepts of using physical features for datums and bonus tolerance.	13	8 (61.5)	5 (38.5)	.692	.50**
50. 3D modeling courses taught online should provide instruction on troubleshooting and correcting common modeling errors.	13	12 (92.3)	1 (7.7)	9.308	.01
51. Historical information and new directions for the 3D modeling industry should be included in online instruction.	13	7 (53.8)	6 (46.2)	.077	.50**

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

Table 14 (continued)

Components	N	Acpt. (%)	Rejct.(%)	X ²	p<.05
52. 3D modeling concepts should include real-world problem solving related to codes and standards, strength of materials, and common manufacturing practices.	13	11 (91.7)	1 (8.3)	8.333	.01
53. CAD programs containing specific design components or "tool boxes" should be clearly identified and explained in online instruction.	13	11 (91.7)	1 (8.3)	8.333	.01
54. Drawing standards should be included in online 3D modeling courses.	13	11 (84.6)	2 (15.4)	6.231	.05
55. Instruction on multiviews and isometric assembly views-manually and using software-should be included in online instruction.	13	10 (76.9)	3 (23.1)	3.769	.10**

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: * Denotes new or modified components approved by the review panel for use in this round.

Note: **Denotes components with a probability value greater than .05. These components were eliminated from the final inventory of best practices.

CHAPTER SUMMARY

This chapter provided detailed information pertaining to the findings of the Demographics Questionnaire and all rounds in this modified Delphi study. Again, fifty-two respondents submitted their demographic information. Of the fifty-two respondents, 62% (N=32) were selected to participate based on the criteria set forth in Chapter 3 of this study.

Round One of this study presented data on the number of panelist that elected to keep, reject, or modify the components presented in the questionnaire. The modifications for Round One components were identified and explained, and the suggested new components for the Round Two questionnaire were also outlined. Results from the questionnaire yielded fourteen modified components and twenty-seven new components.

The second round of this study asked expert panelists to rate each component based on a five-point scale. They were also permitted to submit additional comments, suggestions, or new components to be considered for the subsequent round. After analyzing the data and reviewing the literature once more, categories were collapsed, thus preparing each component for the Cronbach's Alpha analysis. The rated components provided the data for the employment of the analysis. The results of this round included nine modifications and fifteen new components.

After tabulating all data received from Round Two, eliminating the components no longer needed, and receiving approval from the review panel, the final round was made accessible to the expert panel. This questionnaire was comprised of 66 total items, 11 demographic questions. Following the completion of the demographics questions, participants were required to *Accept* or *Reject* the components outlined for final consensus. A

Chi-Square analysis was used to demonstrate that consensus of the remaining components was achieved. The analysis resulted in the elimination of 27% (n=15) of the Round Three components. The remaining forty components were listed as the final inventory of best practices for developing 3D modeling or comparable engineering graphics courses for hybrid or fully online instruction.

CHAPTER 5: SUMMARY, CONCLUSIONS & RECOMMENDATIONS

INTRODUCTION

As the educational landscape continues to change, the methods used to convey instruction are evolving as well. Twenty-first century learners have reevaluated the ways in which they are being educated and have begun to seek other avenues beyond the traditional brick and mortar for acquiring that education. Because online teaching and learning has become a viable and more flexible option for acquiring an undergraduate or graduate degree (Beldarrain, 2006), programs using the traditional approach to instruction have begun to explore nontraditional education environments such as online teaching, in order to remain competitive.

With the presence of online learning continuing to expand, engineering graphics educators have also begun to consider ways for developing 3D modeling courses and comparable engineering graphics courses for online instruction. Scales, Petlick, and Clark (2005) noted that for engineering and technical graphics, the greatest improvement towards course teaching and course listings is the development of online instruction and tutorials. Although a great feat if implemented, few educators in engineering graphics have sought to develop 3D modeling for online instruction and little research has been conducted on a practicable methodology specific to the field of engineering graphics. As indicated in the literature, the challenge with implementing these types of courses online has been the complexity of the subject matter in tandem with deciphering through the multitude of instructional tools that can be incorporated (Totten & Branoff, 2005; Connolly & Maicher, 2003).

PURPOSE OF THE STUDY

Considering the growing demand for teaching engineering graphics online, the purpose of this research study was to identify a practical inventory of best practices for developing modeling courses for online environments that could address the unique challenges engineering graphics educators face when developing for hybrid or fully online instruction. In order to formulate the inventory of best practices, a modified Delphi methodology was conducted. A panel of experts from multiple areas of engineering graphics and technology education identified components that should be included or considered in the inventory of best practices using an iterative approach consisting of three rounds. After tabulating and modifying the results from each round based on expert panel responses, content for the subsequent rounds were provided.

Because the goal was to achieve consensus on the components that should be considered or included when developing a hybrid or fully online 3D modeling course, various statistical analyses were employed to validate consensus. The final inventory displays components derived from a learner-centered framework, course design including instructional technologies, and drawing and modeling content. The inventory of best practices can be utilized to assist engineering graphics educators in the development and implementation of introductory modeling courses for online environments in post-secondary engineering graphics programs.

RESULTS TO RESEARCH QUESTIONS

To ascertain the information necessary for the creation of the inventory of best practices, two research questions that would aggregate data pertaining to a learner-centered

framework for online course development, course design, including instructional technologies, and drawing and modeling content were proposed. A web-based modified Delphi methodology was used to collect data. In order to determine the components that would be retained for the final inventory of best practices, a probability value of .05 or less, utilizing a Chi-Square statistic with one degree of freedom was the determinant. Below are the results for the research questions guiding this study.

Research Question 1

What are the key components necessary for designing a quality introductory modeling course for online environments? Responses for key components encompassed several areas - learner-centeredness, course design, and drawing and modeling content. Components not included as part of the technology components are the findings for this research question. The results are listed in Table 15.

Table 15

Validated Key Components Retained for the Final Inventory of Best Practices

Learner-Centeredness

1. Students should take the initiative to acquire knowledge through identifying, selecting, or constructing a learning pathway from a series of predefined modules guided by the instructor.
2. Students should have an understanding of course standards and objectives in order to establish individual learning goals that are aligned with the course.
3. Students need to be self-motivated and disciplined when taking 3D modeling courses online.

Note: Component numbers align with the Round 3 questionnaire component numbers.

Table 15 (continued)

4. Individual learner experiences should be valued and considered in online 3D modeling courses.

5. Students should understand, and find relevance in the application of their coursework.

Course Design

6. Ensuring sufficient participation through course activities, group discussions, and collaborative projects is essential in a hybrid or fully online modeling course.

7. Online modeling courses should promote creative and critical thinking through independent and/or collaborative work.

8. Information constructed from the community of learners (course participants) should be promoted and included in instruction or serve as supplemental material for online modeling courses.

9. Assessments should be considered as part of the instructional design process when developing online instruction.

10. Assessments should periodically be given in the form in which the learning has been obtained.

11. Assessments should be developed from all course activities including project-based learning objectives.

12. Assessments that provide specific guidance to correct errors should be context dependent and used to provide periodic feedback to learners.

13. 3D modeling content delivered online should derive from course objectives and course competencies.

14. Sketching activities should be used as a supplement when teaching 3D modeling online.

16. Online modeling courses should have a clear feedback path established that allows students to communicate with the instructor/professor.

Note: Component numbers align with the Round 3 questionnaire component numbers.

Table 15 (continued)

17. Online modeling courses should support and provide collaborative project work for small teams/groups.

19. Adequate internal and external links, and required and supplemental readings, should be included in online modeling learning.

20. Establishing and encouraging interactions in the online environment is important when addressing and solving real world issues.

22. Peer-to-peer interactions should be fostered and designed into hybrid and online instruction.

23. Communications with the course professor and other instructors knowledgeable of the subject matter should be encouraged.

24. Collaborative discussions and demonstrations amongst class members and/or assigned groups should be included and utilized for self-teaching amongst peers.

33. Online interactions include accessing content through a course website.

Drawing & Modeling Content

42. Visualization for 3D models should be taught in an online modeling course.

44. The modeling thought process should be included in online instruction.

45. The application of 3D modeling in practical applications of design and manufacturing should be demonstrated.

46. Modeling theory and strategies should be included in online instruction.

48. Instruction about the different types of 3D modeling (parametric modeling, constraint based modeling, boundary representation and wireframe/surface modeling, and constructive solid geometry modeling) should be included in an online modeling course.

Note: Component numbers align with the Round 3 questionnaire component numbers.

Table 15 (continued)

50. 3D modeling courses taught online should provide instruction on troubleshooting and correcting common modeling errors.

52. 3D modeling concepts should include real-world problem solving related to codes and standards, strength of materials, and common manufacturing practices.

53. CAD programs containing specific design components or "tool boxes" should be clearly identified and explained in online instruction.

54. Drawing standards should be included in online 3D modeling courses.

Note: Component numbers align with the Round 3 questionnaire component numbers.

Conclusions for Research Question 1

When examining the findings collectively and comparing them to what has been found in the literature, several factors are evident. McCombs and Vakili (2005) posited that when designing online instruction, learner-centered principles determine the direction of curricula (McCombs & Vakili, 2005). Paralleling the position of McCombs and Vakili, responses from the expert panel with a p-value of .05 or less were retained. This resulted in the keeping of all *Learner-Centeredness* components. Additionally, the findings revealed components two and three as having 100% acceptance from the expert panel, leading to the highest p-value of .001.

The results also revealed 65% (n=26) of the components in the *Course Design* category to be statistically significant. Of the twenty-six components retained, nine were technology related and therefore not included in this conclusion. The remaining seventeen components in the *Course Design* category covered topics such as assessment (components

9, 10, 11, 12), content development (components 7, 13, 14, 19, 33), and interactions (components 6, 8, 16, 17, 20, 22, 23, 24). Of those subcategories, as identified by the researcher, 41% (components 9, 10, 13, 19, 16, 20, 23) received 100% acceptance from the expert panelists.

When looking more closely at the results for each subcategory, it is interesting to note that although expert panel members agreed on how assessments should be included in instruction (components 10, 11, 12), there were no suggestions made on any tools that could be used to assess student work. Members of the expert panel also refrained from including any specific information pertaining to the utilization of automated assessments (Fan, 2007; Fan & Tanimoto, 2007; Connolly & Maicher, 2003, 2003, 2005), peer assessments (Keppell, et al., 2006), self-assessments (Kemppainen and Hein, 2008) or constructed responses (Jordan & Mitchell, 2009) as cited in the literature.

In the *Drawing and Modeling* category expert panel members responded to fourteen components. After employing the Chi-Square analysis and determining the p-value, 64% (n=9) of those components remained (components 42, 44, 45, 46, 48, 50, 52, 53, 54). Of the nine remaining components, three (components 44, 46, 48) received 100% agreement. When comparing the nine drawing and modeling components to the literature, the components retained correspond well with the literature, as discussed below.

Ault (1999) suggested that greater emphasis on solid modeling concepts, parametrics, and modern graphical analysis methods are to be included in instruction (component 48). Paralleling Ault (1999), Branoff, Hartman, and Wiebe (2002), agreed that visualization (component 42) also remain in 3D modeling instruction. Branoff, Hartman, and Wiebe

(2002), also suggested that manufacturing processes (components 45 and 52), the decision making processes associated with the creation of models (component 44), and the development of techniques or strategies associated with the purpose of specific model creation (component 46) be taught in an introductory 3D modeling courses. The remaining components, although not directly found in this literature review achieved consensus from the expert panel.

Out of the five components (43, 47, 49, 51, 55) that were eliminated from the final inventory, components 47 and 55 were most surprising. Component 47 stated that online courses should demonstrate software specific techniques. Because most introductory 3D modeling courses utilize software to create models, the skills developed in the traditional face-to-face course using software should transfer into the online environment as well. Since the understanding of and the manipulation of the software are important when developing models, equally important is demonstrating software specific techniques in order to complete the tasks. These techniques could be displayed using screencasts, animations, or demonstration videos. When looking at the exclusion of this component in tandem with components retained and eliminated, a reasonable explanation may be that the expert panel did not establish the connection between what the technologies are, screencasts, animations, and demonstration videos, and how they could be used to demonstrate software specific techniques.

Component 55 highlighted the inclusion of multiview and isometric assembly view drawing, both manual and software-derived. When trying to conceptualize 3D models, the approach has often been to use multiview drawings to identify each side or plane of the solid

object, followed by the creation of an isometric drawing from those planes. The process could also occur in the reverse order. Repeated exposure to this process not only reinforces one's ability to visualize 3D models, but also aids in decreasing the complexity of creating 3D models when manually drawing or utilizing software. It is important to note that the literature supported the use of components 47 and 55, in online introductory 3D modeling courses (Totten & Branoff, 2005; Connolly & Maicher, 2005; Branoff, Hartman, and Wiebe, 2002).

Research Question 2

What technologies are essential for the instructional design of the 3D modeling course and implementation of the course design? There are a number of instructional technologies that could be used when developing or teaching a course fully online or as a hybrid. Although the expert panel suggested many other technologies, those indicated below met the p-value for retaining each of the components. Based on the statistical analysis of participant responses, the validated inventory of technological components is found below in Table 16.

Table 16

Validated Technology Components Retained for the Final Inventory of Best Practices

21. Online interactions with course content include the use of a *Learning Management System (LMS)*.

25. *Application sharing tools* should be used for live demonstrations of course software.

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: Italics denote the technology or describes the technology to be used.

Table 16 (continued)

26. *Interactive exercises* that react to student input and provide constructive, context-sensitive feedback to the student should be included in online instruction.
28. Online modeling courses should utilize *discussion boards* to pose thoughts/questions, evoke responses, and/or address issues.
34. *Application sharing tools* should be utilized to assess the student's knowledge of software application.
36. Modeling content delivered asynchronously should include *lecture capture videos*.
38. *Demonstration videos* displaying hands-on sketching practices or techniques should be included in online instruction.
39. *Screencasts* should be included in online modeling content to visually present recorded step-by-step processes/demonstrations of course software usage.
40. Online modeling courses should incorporate *simulations/animations* to demonstrate the internal processes of model building.
-

Note: Component numbers align with the Round 3 questionnaire component numbers.

Note: Italics denote the technology or describes the technology to be used.

Conclusions for Research Question 2

The results from Table 16 were extracted from the *Course Design* category. Of the nine components only one (component 40) received 100% agreement amongst the expert panelists. When comparing the components to the information that can be found in the literature, all components that were retained are described in the literature (Maloney, 2007; Totten & Branoff, 2005; Ashely, 2003; Latchman, et al., 1998). The most interesting results, however, pertained to the eliminated components.

During development of courses for online teaching and learning, Web 2.0 technologies related to collaborative tools such as wikis and online whiteboards, real-time applications, live chat and communications, podcasts, etc., should be included during instruction to create a richer, more dynamic learning environment. The expert panelists did not strongly and collectively elect any of these instructional technology tools. All technology related components (27, 29, 30, 31, 32, 35, 37, 41) that were not retained for the final inventory of best practices are the very ones that the literature focused on and supported in great detail (Cole, 2009; Fernandez, Sima, & Sallon, 2009; Lee, McLoughlin, & Chan, 2008; Carpenter & Roberts, 2007, Parker & Chao, 2007).

It is important to also note the elimination of component 15, which stated that content should be delivered asynchronously utilizing multiple methods of delivery. Multiple methods of delivery are considered to be multi-dimensional, meaning that information is distributed and received through multiple channels (Bonk & Wisher, 2000). When considering multiple channels to disseminate, exchange, and construct information and knowledge, many of the Web 2.0 tools identified could facilitate those processes. It can be concluded that a cause for elimination of component 15 may be based on one's view of how to utilize these tools. Many of the Web 2.0 collaborative tools could be viewed as tools to use synchronously, not asynchronously. Therefore, expert panel members may deem the use of those tools, although effective for transmitting and receiving information multi-dimensionally, as inappropriate for asynchronous learning.

Although the expert panel members did not state any reasons for eliminating component 15 or any of the Web 2.0 collaborative tools, additional causes for elimination

may include insufficient time for implementation, the cost associated with integrating the technology tool into a 3D modeling course, and/or lack of knowledge of the capabilities of the technology tools. Other viable options may include previous unconstructive experience utilizing the tools, and the Web 2.0 collaborative tools inadequacy in a 3D modeling environment.

IMPLICATIONS FOR ENGINEERING GRAPHICS EDUCATORS

The purpose of this study was to utilize the experiences of educators in engineering graphics education to develop an inventory of best practices for online teaching and/or development. The potential outcome of this research was not only to contribute to the growing body of engineering graphics education literature, but to also have this inventory serve as a blueprint for online course development for novice or experienced educators.

While this inventory does not exhaust every instructional technology that currently exist, nor every possible concept in an introductory 3D modeling course, it does however provide valuable insight about current technologies, learner characteristics, and content topics that should be incorporated into, or at least considered, for current and future instructional practices. Engineering graphics educators seeking to transition from face-to-face to online instruction or revise an existing introductory 3D modeling course can utilize this inventory as a guide or blueprint for course development.

RECOMMENDATIONS FOR FUTURE RESEARCH

At the time this study began, no previous research identified a checklist or inventory for online course development specifically designed for the area of 3D modeling or comparable Engineering Graphics education courses. There were however, many resources

that provided general information pertaining to effective online course development. The results of those studies combined with the findings of this research study serve as the basis for recommendations for future research. Recommendations include the following items below.

1. A follow-up study on the effects of using this inventory to determine any observed differences of learning outcomes based on pre and post data collection. After creating an introductory 3D modeling course or comparable course utilizing the information provided in this inventory, data can be collected on student retention. This information could be useful in determining the most appropriate supplemental materials, the areas students need additional support on, and the overall effectiveness of the instruction; all of which directly effect retention of learning.
2. For comparative analysis, this study should be duplicated utilizing professionals working in engineering graphics as the target population. In order to determine whether or not graduates possess the necessary skills for employment in industry, professionals in engineering graphics could lend their experiences and knowledge toward content and course design. This type of study could be useful in recognizing and closing the gaps between academia and industry.
3. A follow-up study should be conducted on faculty development training for engineering graphics educators, as it relates to understanding the usefulness of current and emerging instructional technologies into online teaching. Considering the number of technologies that were eliminated in this study, aggregating additional information on the type of instructional technology training provided to faculty could give insight

- on their perspective of why various technologies should or should not be included in online teaching. This information could then be utilized to further determine the professional development needs of faculty members.
4. A follow-up study should also be conducted on faculty development training for engineering graphics educators, pertaining to the incorporation of current and emerging instructional technologies for online teaching. To understand why technologies should be utilized in instruction is quite different from understanding how these technologies can be used. This type of follow-up study could ascertain information about whether or not faculty members receive training, support, or information about different methodologies for incorporating technology into online teaching based on online teaching pedagogy. Again, this information could be useful in determining training needs for faculty members.
 5. Future research should be conducted to investigate the readiness of engineering graphics faculty members for online teaching and learning. Many times, faculty members are thrust into online teaching without receiving proper training on online teaching pedagogy, instructional/course design, or technology implementation. The result is often inadequate or ineffective instruction. To combat this issue, a study examining the readiness of faculty members could provide insight on how to prepare for teaching in the online environment.
 6. Future research should be conducted to revise or update this inventory. Given that innovative technologies are constantly being developed to enhance and improve online teaching and learning, this inventory may need to be revised to address

emerging technologies, new methods for utilizing existing technologies, and/or improvements in online teaching techniques.

STUDY CONCLUSIONS

The results of this study suggested that engineering graphics educators believed that when developing for hybrid or online instruction learner-centered principles such as student's taking the initiative to acquire knowledge, the importance of valuing individual learner experiences, providing relevant meaning in the application of coursework, and conveying clear and concise information about course standards and objectives was important in developing a quality course. When developing courses utilizing the learner-centered framework as the core for development, it creates a platform for self-direction that can be conducive and supportive to the learner (Mccombs & Vakili, 2005). Additionally, the learner-centered approach also helps to identify the best teaching and instructional design practices that increase motivation, thus achieving higher levels of learning.

When utilizing the learner-centered approach as the basis for course design, research has shown that the approach is enhanced if applied in a context where collaboration between instructor/facilitator and other individuals involved in the learning offers supportive environments (Anderson, 2008; McCombs, 2003). Now considering this notion in tandem with the results of *Course Design*, which included instructional and interactive technologies, a major cause for questioning was noted. Although the panel suggested that peer-to-peer interactions should be fostered, and collaborative discussions and demonstrations amongst class members should be included in online courses, the technologies that could foster such collaborations, such as wikis, real-time applications, synchronous communications, blogs,

etc., were eliminated due to low agreement amongst the expert panel members. So considering this, the researcher concluded several possible reasons; insufficient time for implementation, the cost associated with integrating the technology tool into a 3D modeling course, and unconstructive experience utilizing the tools. Additional causes included the expert panelists' understanding of how to best utilize the collaborative tools in a course that is more structured and tactical than most, and possibly, the tools overall inadequacy in a 3D modeling environment.

Utilizing the learner-centered approach as the basis for course development also provides insight on how to support the learner by providing multiple ways of acquiring course content. Bonk and Wisner (2000) stated that the pedagogical strategies encasing the learner-centered approach references the needs of the learners including their individual learning styles. This implies that the instructor should consider designing the online environment including multiple modalities, languages, and types of expression used to understand, interpret, and construct new forms of knowledge. Evident through the results of this study, the expert panelists collectively agreed on several methods for acquiring course information which included utilizing a Learning Management System, using application sharing tools, providing interactive exercises that react to student input, exchanging ideas via discussion boards, delivering content using lecture capture videos, recording demonstration videos for sketching practices, creating screencasts to present step-by-step processes, and incorporating simulations and /or animations in instruction.

Interesting to note here, was that although engineering graphics educators agreed on acquiring course content utilizing multiple methods of instructional delivery, there was low

agreement on collaborative learning opportunities. It appeared that the expert panelists' perspective on learning, possibly, did not move beyond that which was derived from their teaching. The expert panelists therefore, gave the impression that although they have embraced online teaching as a viable delivery method, their model for teaching has not necessarily progressed toward that which Knowles (1975) coined, and Clark (2003), Ferguson (2001), Lee and Gibson (2003), and many others explicated. This model, which can primarily be described today as a modern-day approach to teaching, especially in the online context, is a multi-dimensional approach to learning. Learning that is not only acquired from the instructor, but all those actively participating in the learning environment.

In conclusion, teaching in an online environment is not merely just utilizing a different medium to deliver instructional material, “the medium itself has a transformative effect” (Otte & Benke, 2006, p. 24) grounded in learner-centered principles. As a core principle for online course development, in tandem with the inventory of best practices, novice and experienced engineering graphics educators should continue to utilize the learner-centered approach to develop online courses for engineering graphics education.

CHAPTER SUMMARY

This chapter provided detailed explanations about the findings and conclusions of the research questions guiding this study. The chapter began with an overview of the rationale and purpose of conducting this study, followed by the research questions, findings, and conclusions. The researcher reemphasized the use of the Chi-Square statistical analysis to determine how the components would be retained for the final inventory of best practices. As indicated by the results of the Chi-Square analysis, forty components in the areas of *Learner-*

Centeredness, Course Design, and Drawing and Modeling Content were retained for the final inventory of best practices.

Following the conclusions for the research questions, implications for engineering graphics educators were discussed. The researcher stated that the inventory could serve as a blueprint for novice or experienced educators when creating hybrid or online introductory 3D modeling courses or comparable engineering courses. Additionally, the inventory could provide an overall strategy for course development, assist in identifying important learner characteristics, identify some of the most effective instructional and interactive technologies, and outline some of the most important content areas.

Lastly, the recommendations for future research were outlined. Based on the findings of this study, the researcher identified six potential follow-up studies that could be conducted. Those studies included using the inventory to determine any differences in learning based on pre and post data, replicating the study using professionals in engineering graphics education, examining faculty development training on understanding the usefulness of current and emerging instructional technologies as they pertain to online teaching, examining faculty development training on how to incorporate current and emerging technologies into instruction, investigating the readiness of faculty members considering teaching online, and revising or updating the inventory of best practices.

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APPENDICES

APPENDIX A

Institutional Review Board Application
Institutional Review Board Approval
Institutional Review Board Extension Approval

IRB#

**North Carolina State University
Institutional Review Board for the Use of Human Subjects in Research
REQUEST FOR EXEMPTION (Administrative Review)**

GENERAL INFORMATION

1. **Date Submitted:** 10/2/09
2. **Title of Project:** Best Practices for Designing Online Learning Environments for 3D Modeling Curricula: A Delphi Study
3. **Principal Investigator:** Kathleen H. Mapson
4. **Department:** Math, Science, & Technology Education
5. **Campus Box Number:** Box 7801
6. **Email:** kdharrel@ncsu.edu
7. **Phone Number:** 919-217-3461
8. **Fax Number:** NA
9. **Faculty Sponsor Name and Email Address if Student Submission:**
Dr. Aaron Clark-aaron_clark@ncsu.edu; Dr. Jeremy Ernst-jeremy_ernst@ncsu.edu
10. **Source of Funding? (required information):** NA
11. **Is this research receiving federal funding?:** No
12. **If Externally funded, include sponsor name and university account number:** NA
13. **RANK:**
 - Faculty
 - Student: Undergraduate; Masters; or X-PhD
 - Other (specify): _____

As the principal investigator, my signature testifies that I have read and understood the University Policy and Procedures for the Use of Human Subjects in Research. I assure the Committee that all procedures performed under this project will be conducted exactly as outlined in the Proposal Narrative and that any modification to this protocol will be

submitted to the Committee in the form of an amendment for its approval prior to implementation.

Principal Investigator:

Kathleen H. Mapson _____
(typed/printed name) (signature) (date)

*As the faculty sponsor, my signature testifies that I have reviewed this application thoroughly and will oversee the research in its entirety. I hereby acknowledge my role as the **principal investigator of record**.*

Faculty Sponsor:

Dr. Aaron Clark _____
(typed/printed name) (signature) (date)

Dr. Jeremy Ernst _____
(typed/printed name) (signature) (date)

***Electronic submissions to the IRB are considered signed via an electronic signature**

PLEASE COMPLETE AND DELIVER TO:
joe_rabiega@ncsu.edu or Institutional Review Board, Box 7514, NCSU Campus
(Administrative Services III, Room 245)

For SPARCS office use only

Regulatory Compliance Office Disposition

Exemption Granted Not Exempt, Submit a full protocol

Exempt Under: b.1 b.2 b.3 b.4 b.6

IRB Office Representative

Date

Project Description: *(Describe your project by providing a brief summary and answering the requests for information below).*

1. Project Summary. Please make sure to include the purpose and rationale for your study as well as all study activities:

The purpose of this survey-based research study is to develop a list of best practices for designing online learning environments for 3D modeling curricula. This list of best practices will serve as a guide or checklist to assist post-secondary educators in identifying instructional design components, drawing and modeling topics, and interactive technologies, all of which are essential for the development of a quality 3D modeling or engineering graphics course taught online.

2. Description of participant population, including age range, inclusion/exclusion criteria, and any vulnerable populations that will be targeted for enrollment.

Participants for this study may include post-secondary educators in engineering design graphics, career and technical education, and other members of the American Society of Engineering Education. Criteria for participation in this study include a Bachelor of Science or Art, two or more years of professional organization affiliation, and two or more years developing or teaching engineering design graphics courses or related courses in an online environment.

3. Description of how potential participants will be approached about the research, and how informed consent will be obtained. Alternatively, provide an explanation of why informed consent will not be obtained.

Potential participants will be approached about the research study through email. This email will be an all call for participation. Potential participation of an individual may also be through recommendation of a colleague. The information in the email will consist of the significance and rationale for the study as well as the research methodology to be utilized to collect the data. Consent will be obtained from participant responses with an acceptance, rejection, or none response about research participation.

4. Description of how identifying information will be recorded and associated with data (e.g. code numbers used that are linked via a master list to subjects' names). Alternatively, provide details on how study data will be collected and stored

anonymously (“anonymously” means that there is no link whatsoever between participant identities and data).

The researcher will have a master list of participants that will be concealed off campus in a locked file cabinet. The participants will remain anonymous to one another through out the research study. The demographics information collected for the master list will be used to identify those that meet the criteria for participation in this survey-based research study. The master list will not be used to identify those that have or have not completed the survey. The master list will be destroyed at the conclusion of the study.

5. Description of all study procedures, including topics that will be discussed in interviews and/or survey instruments.

This study will use a Delphi methodology for data collection consisting of three rounds of questioning. Survey instruments developed for this study are based on the responses from the previous survey round. The topics to be included throughout the study include modeling content, instructional design components, and interactive technologies. The initial survey to be received by the study participants will be a demographics questionnaire consisting of questions about their educational background and experiences with developing, teaching, and/or implementing courses or online courses. As the rounds of questions continue, the responses will be aggregated and condensed, ultimately creating a compounded list of best practices.

6. Will minors (participants under the age of 18) be recruited for this study: No
7. Is this study funded? No If yes, please provide the grant proposal or any other supporting documents.
8. Is this study receiving federal funding? No
9. Do you have a significant financial interest or other conflict of interest in the sponsor of this project? No
10. Does your current conflicts of interest management plan include this relationship and is it being properly followed? No

11. HUMAN SUBJECT ETHICS TRAINING

*Please consider taking the [Collaborative Institutional Training Initiative](#) (CITI), a free, comprehensive ethics training program for researchers conducting research with human subjects. Just click on the underlined link.

12. ADDITIONAL INFORMATION:

- a) If a questionnaire, survey or interview instrument is to be used, attach a copy to this proposal.
- b) Attach a copy of the informed consent form to this proposal.
- c) Please provide any additional materials (i.e., recruitment materials) that may aid the IRB in making its decision.

**If a survey instrument or other documents such as a consent form that will be used in the study are available, attach them to this request. If informed consent is not necessary, an information or fact sheet should be considered in order to provide subjects with information about the study. The informed consent form template on the IRB website could be modified into an information or fact sheet.*

The Following are categories the IRB office uses to determine if your project qualifies for exemption (a review of the categories below may provide guidance about what sort of information is necessary for the IRB office to verify that your research is exempt):

Exemption Category: (Choose only one of the following that specifically matches the characteristics of your study that make this project exempt)

- X 1. Research conducted in established or commonly accepted educational settings, involving normal educational practices, such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- 2. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
***Please Note- this exemption for research involving survey or interview procedures or observations of public behavior does not apply to research conducted with minors, except for research that involves observation of public behavior when the investigator(s) do not participate in the activities being observed.**

- 3. Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) require(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.

- 4. Research, involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that subjects cannot be identified, directly or through identifiers linked to the subjects.

- 5. Not applicable

- 6. Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the Food and Drug Administration, or approved by the Environmental Protection Agency, or the Food Safety and Inspection Service of the U.S. Department of Agriculture.

NC STATE UNIVERSITY

Sponsored Programs and
Regulatory Compliance
Campus Box 7514
2701 Sullivan Drive
Raleigh, NC 27695-7514

919.515.2444
919.515.7721 (fax)

From: Carol Mickelson, IRB Coordinator
North Carolina State University
Institutional Review Board

Date: October 27, 2009

Project Title: Best Practices for Designing Online Learning Environments for 3D Modeling
Curricula: A Delphi Study

IRB#: 1162-09-10

Dear Ms. Mapson,

The research proposal named above has received administrative review and has been approved as exempt from the policy as outlined in the Code of Federal Regulations (Exemption: 46.101. b.2). Provided that the only participation of the subjects is as described in the proposal narrative, this project is exempt from further review.

NOTE:

1. This committee complies with requirements found in Title 45 part 46 of The Code of Federal Regulations. For NCSU projects, the Assurance Number is: FWA00003429.
2. Any changes to the research must be submitted and approved by the IRB prior to implementation.
3. If any unanticipated problems occur, they must be reported to the IRB office within 5 business days.

Please forward a copy of this letter to your faculty sponsor. Thank you.

Sincerely,

Carol Mickelson
NCSU IRB

NC STATE UNIVERSITY

Campus Box 7514
Raleigh, North Carolina 27695-7514

919.515.2444 (phone)
919.515.7721 (fax)

From: Carol Mickelson, IRB Coordinator
North Carolina State University
Institutional Review Board

Date: 12/13/10

Project Title: Best Practices for Designing Online Learning Environments for 3D Modeling
Curricula: A Delphi Study

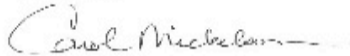
IRB #: 1162

Dear Ms. Mapson, Dr. Clark, and Dr. Emst:

Your addendum to the study named above has been reviewed by the IRB office, and has been approved. The addendum does not change the original IRB exemption status of this project and you are free to proceed with your study.

If you have any questions please do not hesitate to contact the IRB office at 919.515.4514.

Sincerely,



Carol Mickelson
NC State IRB

APPENDIX B

Email Notification to American Society of Engineering Education (ASEE)
Email Notification to American Design Drafting (Digital) Association (ADDA)
Email Notification to Potential Panelists - Overview of the Study
Email Notification to Review Panel for Acceptance as a Reviewer
Study Overview
Informed Consent for Participation
Demographics Questionnaire

Note: Email Notification to EDGD (Engineering Design Graphics Division of the American Society for Engineering Education)

Dear Educators,

I need your assistance with a research study I am currently conducting. The study seeks to identify the best practices for developing online courses for three-dimensional modeling curricula and is the topic of my dissertation for the Technology Education program at North Carolina State University. For this study a panel of experts and a review panel from post-secondary institutions experienced in teaching and/or developing fully online or hybrid courses in three-dimensional modeling or related engineering graphics education courses will be used to identify components for developing quality three-dimensional modeling courses for online delivery. The information collected from the experts will be compiled into a list of best practices and serve as an outline or blueprint for course development. The best practices list endeavors to ease the process of determining topics and the most useful technologies for effective online teaching, whether transitioning from face-to-face to online learning or developing new online courses.

In order to gather the information needed in this study, a modified Delphi will be utilized. The Delphi methodology is a survey-based process consisting of rounds of questioning; each subsequent round is developed from the responses of the previous round. This research study will consist of three rounds of questioning. Each round should only take five to ten minutes to complete and each participant will have two weeks from the date the survey is granted to complete and submit the survey. Instructions for each round will be included.

Please review the attached study overview and informed consent form. The informed consent will provide directions for participation in the "consent" section of the document. If you decide to participate after reading the attached documents, please visit the link below to submit your demographic information by March 19, 2010.

http://www.surveymonkey.com/s/3DMOG_Demographics

Thank you in advance for considering to participate in this research study.

Kindest Regards,
Kathleen H. Mapson
Doctoral Candidate
Technology Education-Ed.D. Program

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Email Notification to ADDA International (Executive Director, American Design Drafting (Digital) Association)

Greetings Dr. Parker,

I spoke with your assistant about a week ago concerning my doctoral dissertation study. She informed me of your email and stated that this was the best possible way to contact you.

I am conducting my doctoral research on developing introductory 3D-Modeling courses for online teaching and learning. For this study I will be using a web-based modified Delphi methodology to collect information from study participants. I have contacted you in order to see if it is possible to subscribe to the list-serv for your organization in order to contact members for participation in this study. If this is not possible, I would like to know if you or someone you know could submit this information on my behalf.

Attached is a document that describes the research study with instructions on how to proceed. Any help would be greatly appreciated. Thank you for your time.

Kindest Regards,
Kathleen H. Mapson

Kathleen H. Mapson
Doctoral Candidate
Technology Education
North Carolina State University

Note: Email Notification to Potential Panelist - Overview of the Study

Dear Educators,

Many thanks to those of you who responded to my call for participation for this doctoral research study. After a complete review of the demographics survey responses, you will be contacted by the email address you provided.

For the educators that have not submitted your demographic information and would still like to participate, the survey will remain open until the responses have all been reviewed. I will notify you all when the demographics survey will officially close.

http://www.surveymonkey.com/s/3DMOG_Demographics

Attached is an overview of the study and the informed consent for your review.

I am grateful for your help and willingness to participate in this doctoral study. I believe that the results of this study will contribute to the field of Engineering Graphics Education and its growing body of literature.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education Program

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Email Notification to Review Panel for Acceptance as a Reviewer

Dear Educators,

The methodology selected for this research study requires a Review Panel and an Expert Panel of participants. The Review panel experts examine all surveys for clarity, format, and accessibility while the Expert panel provides responses to the surveys. Selection for the review panel is completely random and is based on the entire pool of qualified participants.

It is my hope that you will accept the position of reviewer for this study. If not please inform me of your decision within 48 hours so another qualified participant can be randomly selected. If you decide not to serve as a reviewer, it is also my hope that you will still serve as an Expert panel member. If I do not receive a response of rejection, I will assume that you have accepted the responsibility of reviewer for this study.

If your decision is to serve as reviewer, please visit the link below and provide your feedback about the survey. Please submit your feedback by Friday, April 23, 2010. This is the only round that will provide a week for feedback response submissions.

http://www.surveymonkey.com/s/3DMOG_Round1

Attached are the instructions for the Round 1 Questionnaire.

Thank you again for your time, expertise, and participation in this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Study Overview

Dissertation Title

Best Practices for Designing Online Learning Environments for 3D Modeling Curricula: A Delphi Study

Doctoral Researcher: Kathleen H. Mapson

University: NCSU, College of Education, Dept. of Math, Science, & Technology Education

Major: Technology Education

Introduction

The presence of technology in society has forced a dramatic change in the teaching methods of engineering graphics educators in higher education. As these technologies continue to evolve and materialize into a system that was previously unimaginable, engineering graphics educators should strive to deliver instruction in a manner that is relevant and accessible to today's learners. Engineering graphics educators must not only consider the traditional class settings and methods of instructional delivery, but must also explore nontraditional education environments such as online learning.

Statement of the Problem

Engineering graphics educators are faced with a dilemma when developing 3D modeling courses for online instruction. Because a vast array of instructional methodologies and technological tools exist many engineering graphics educators are uncertain about which of these is most appropriate for selection and utilization in course design. To better understand and identify the components for developing an effective, interactive, online course for 3D modeling curricula, these elements will have to be investigated.

Purpose of the Study

The purpose of this research is to develop a list of best practices for designing online learning environments for 3D modeling curricula. This list of best practices will serve as a guide or checklist to assist post-secondary educators in identifying instructional design components, drawing and modeling topics, and interactive technologies, all of which are essential for the development of a quality 3D modeling or engineering graphics course taught online.

Research Questions

The questions guiding this study are listed below.

1. What are the key components necessary for designing a quality introductory modeling course for online environments?
2. What technologies are essential for the instructional design of the modeling course and implementation of the course design?

Instrument Accessibility

A web-based Delphi method will be used to generate and aggregate responses in an effort to

reach consensus on the best practices for designing online environments for 3D modeling curricula. A Delphi is a series of interactive questions between the researcher and the study participants with the objective of obtaining consensus from expert panelists.

North Carolina State University
INFORMED CONSENT FORM for RESEARCH – DELPHI STUDY

Title of Study: Best Practices for Designing Online Learning Environments for 3D Modeling Curricula: A Delphi Study

Principal Investigator: Kathleen H. Mapson
Faculty Sponsor: Dr. Aaron C. Clark & Dr. Jeremy V. Ernst

We are asking you to participate in a research study. The purpose of this study is to identify the best practices for developing modeling courses for online instruction.

INFORMATION

If you agree to participate in this study, you will be asked to participate in a web-based Delphi study. This Delphi study will consist of three rounds of questions. These questions are posed to a group of experts in the field of Engineering Graphics Education in an effort to reach consensus as to what components are required to develop a quality online 3D modeling course.

RISKS

There are no risks associated with completing the survey.

BENEFITS

There is no direct benefit expected to the subject, but knowledge may be gained that could help others.

CONFIDENTIALITY

The information in the study will be kept confidential. Data will be secured at an off-campus location. No reference will be made in any report, which could link your responses to the study.

CONTACT

If you have questions at any time about the study or the procedures you may contact the researcher, Kathleen H. Mapson at kdharrel@ncsu.edu.

PARTICIPATION

Your participation in this study is voluntary; you may decline to participate without penalty. If you decide to participate, you may withdraw from the study at any time without penalty. Should you decide to withdraw from the study before data collection is completed your data will be destroyed.

CONSENT

“I have read and understand the above information. I have received a copy of this form. I agree to participate in this study with the understanding that I may withdraw at any time.” Please respond with an acceptance or rejection. A non-response will signify a rejection of participation. A response of "Agree to Participation" will signify an acceptance to participate in this study.

Demographics Questionnaire for Delphi Study

Instructions

In order to acquire information about you and others participating in this study, the Demographics Questionnaire, is the first instrument that requires completion. After completing your demographics Questionnaire to the best of your ability, please click Done. You should receive a Thank You receipt for your submission.

1. Please provide your email address. All participants remain confidential and anonymous to one another. This information will be used to contact you when questionnaires are available and to serve reminders for questionnaire completion.
2. Which title most accurately describes your position? *(If other, please type response in the textbox provided)*
 - a. Engineering educator
 - b. Engineering graphics educator
 - c. Technology educator
 - d. Other
**Textbox for additional response
3. What is the highest degree obtained as of January 2010?
 - a. BS/BA
 - b. MA/MS/MEd
 - c. EdD/PhD
4. List the major area for each degree you hold. *(Please indicate the discipline and name of University your degree was awarded in the textbox provided)*
 - a. BS/BA **Textbox for additional response
 - b. MS/Med **Textbox for additional response
 - c. EdD/PhD **Textbox for additional response
5. List any professional organizations you are affiliated with. *(Please type response in the textbox provided)* **Textbox for additional response
6. Are you currently teaching, developing, or implementing engineering graphics courses?
 - a. Yes
 - b. No
**Textbox for additional response

7. What is your experience with course development for engineering graphics education and/or 3D modeling?
- Less than 2 years
 - 2-3 years
 - 3 years or more
8. Have you ever taught or developed a fully online course? *(If "yes", select your years of experience from one of the answer choices below. If your response is no, type "no" in the additional response box.)*
- Less than 2 years
 - 2-3 years
 - 3 years or more
- **Textbox for additional response
9. Have you ever taught or developed a hybrid course? *(If "yes", select your years of experience from one of the answer choices below. If your response is no, type "no" in the additional response box.)*
- Less than 2 years
 - 2-3 years
 - 3 years or more
- **Textbox for additional response
10. What are your experiences developing courses for online environments, whether revising traditional courses for online teaching or creating a novel course? *(Please type response in the textbox provided)* **Textbox for additional response
11. Have you received any professional development training within the last two years for online course development? *(Please type response in the textbox provided)*
- Yes
 - No
- **Textbox for additional response

APPENDIX C

Email Reminder Notification to Review Panel for Round 1
Instructions for Round 1 of the Study
Thank You Email to Review Panel for Round 1
Email Notification to Expert Panel for Round 1
Gentle Reminder 1 Email Notification to Expert Panel for Round 1
Gentle Reminder 2 Email Notification to Expert Panel for Round 1
Final Reminder Email Notification to Expert Panel for Round 1
Thank You Notification to Expert Panel for Round 1
Round 1 Questionnaire

Note: Email Reminder Notification to Review Panel for Round 1

Dear Educators,

Thank you so much for agreeing to serve as a reviewer for this doctoral study. Many thanks to those of you that have reviewed the Round 1 questionnaire thus far. If you have not had the chance to review the questionnaire and submit your feedback please do so by tomorrow, April 23, 2010. When reviewing the questionnaire you may use the options (Keep & Modify) to submit your feedback OR if you believe the questionnaire does not require modification a response is not required. You may also email any feedback directly to me.

Thank you again for your time, expertise, and participation in this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Instructions for Round I of the Study

Review Panel Members

Listed below are the instructions for completing the first round of questioning for the Delphi research study. Again, this study is designed to determine the best practices for designing online learning environments for introductory 3D modeling curricula.

Instructions: Instruments to be used throughout this study will be accessed via the web. The survey link will be provided. Study participants will be given access to the study instruments for each round.

The Round 1 Questionnaire outlines several categories containing components to be considered or used when developing an introductory 3D modeling course for online teaching and learning. This instrument is titled **Round I Questionnaire**. The first nine categories listed contain common category titles. Also listed are components that are commonly found within each category. These categories and components are examples of the type of information and writing style the study has identified and requires. As a participant on the review panel, you have accepted the responsibility to examine the Round I Questionnaire including the instructions, and provide feedback concerning format, clarity, and accessibility. After you have reviewed this instrument, please email me at kdharrel@ncsu.edu within 48 hours with your feedback. If a response to the questionnaire has not been submitted, I will assume that the survey is lucid and move forward with providing accessibility to the expert panel.

Thank you again for your time, expertise, and participation in the study. If you have any questions please feel free to contact me by phone or email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Note: Thank You Email to Review Panel for Round 1

Dear Educators,

Thank you so much for reviewing the Round 1 Questionnaire. The questionnaire will now be sent to the Expert Panel members. After their responses to the Round 1 Questionnaire have been reviewed, the Round 2 Questionnaire will be developed and forwarded to you for review.

Again, thank you for your time, expertise, and participation in this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Email Notification to Expert Panel for Round 1

Dear Educators,

The methodology selected for this research study requires a Review Panel and an Expert Panel of participants. The Review panel examines all questionnaires for clarity, format, and accessibility while the Expert panel provides responses to the surveys. Selection for the review panel is completely random and is based on the entire pool of qualified participants. Those remaining serve as part of the Expert Panel.

The Round 1 Questionnaire has been approved by the review panel. The questionnaire is now open to collect your responses. Please visit the link below for instructions. Responses must be submitted by Monday May 10, 2010 by midnight. The questionnaire only requires 10-15 minutes of your time.

http://www.surveymonkey.com/s/3DMOG_Round1

Thank you again for your time, expertise, and participation in this study. Your responses are vital to the success of this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Gentle Reminder 1 Email Notification to Expert Panel for Round 1

Dear Expert Panel Members,

Many thanks to those of you who have responded to the Round 1 questionnaire that was made accessible on April 26, 2010. As an expert panelist it is vital for the success of the research that I receive your responses. If you have not yet had a chance to respond, please complete and submit your responses by May 10, 2010.

http://www.surveymonkey.com/s/3DMOG_Round1

I am grateful for your help and willingness to participate in this doctoral study. I believe that the results of this study will contribute to the field of Engineering Graphics Education and it's growing body of literature.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Gentle Reminder 2 Email Notification to Expert Panel for Round 1

Dear Expert Panel Members,

Thank you for the submissions thus far to the Round 1 questionnaire that was made accessible on April 26, 2010. Many of you have yet to respond, but there is still time to do so. As an expert panelist your responses are vital for the success of this research. **If you have not yet had a chance to respond, please complete and submit your responses by Monday, May 10, 2010. The survey will close on May 10 at midnight. Any responses submitted after that time will not be accepted by the survey collector.**

http://www.surveymonkey.com/s/3DMOG_Round1

I am grateful for your help and willingness to participate in this doctoral study. I believe that the results of this study will contribute to the field of Engineering Graphics Education and it's growing body of literature.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Final Reminder Email Notification to Expert Panel for Round 1

Dear Expert Panel Members,

Many thanks to those of you who have responded to the Round 1 questionnaire that was made accessible on April 26, 2010. **Today is the FINAL DAY to submit your responses. If you have not submitted your responses PLEASE do so before midnight.** As an expert panelist your responses are vital to the success of this research. With online teaching and learning becoming a more common practice in higher education, I believe that the results of this research will serve as a foundation for all in Engineering Graphics to build upon. So again, if you have not submitted your responses to the Round 1 Questionnaire PLEASE do so today. It only takes about 15 minutes of your time.

http://www.surveymonkey.com/s/3DMOG_Round1

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Thank You Email to Expert Panel for Round 1

Dear Expert Panel Members,

I sincerely thank all of you that responded to the Round 1 Questionnaire. Your responses are being analyzed in preparation for Round 2.

It is my hope that the response rate for this study will improve. So if you are receiving this email and did not participate in the first round please make the decision to participate in Round 2. Your participation is vital to the success of this study.

Again, many thanks to those that participated.

Kindest Regards,
Kathleen H. Mapson
Doctoral Candidate
Technology Education

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Round 1 Questionnaire

3DMOG-3D Modeling Online Guide

Listed below are the instructions for completing the first of three rounds of questioning for this study. Participation only requires 10-15 minutes of your time. Again, this study is designed to determine the best practices for designing online learning environments for introductory 3D modeling curricula.

Instructions

This questionnaire outlines several categories containing components to be considered or used when developing an introductory 3D modeling course for online teaching and learning. The first nine categories listed, contain common category titles, and components commonly found within each category. These categories and components are examples of the type of information to consider when developing online curricula for introductory 3D modeling courses. The examples also display the writing style the study has identified and requires.

The category and component examples currently listed on the Round 1 Questionnaire can be kept for the subsequent round if you select the **Keep** option beside the desired category title or it's component. You may also completely reject or modify the existing category or component listed by selecting either the **Reject** option or the **Modify** option. If you select the modify option, you must type your revision of the category or component in the textbox provided. Since one of the main objectives of this study is to also **identify new components for existing categories or new categories and their components**, a textbox labeled **Additional Response** has been included. Remember, there is no set number of components required for each category.

After completing the Round 1 questionnaire, click **Done**. You should receive a Thank You receipt for your submission. After the submission receipt displays, another **Done** button will also appear. Please click this button as well to finalize your submission. **Please be sure to submit your responses within two weeks from the date the researcher has notified you of it's availability.**

Round 1 Questionnaire

Please review the following examples of *categories and components to be considered* when developing online curricula for introductory 3D modeling courses for post-secondary Engineering Graphics Education programs. You may keep, reject, or modify the categories and components found in this questionnaire. Please select **Keep** to retain the current category title or component listed, **Reject** if you believe the current category title or component listed does not require consideration, or **Modify** to revise or edit the current category title or component listed in the textbox provided. An **Additional Response** textbox is also provided for you to list any new components that should be considered.

Note: There is no limit on the number of components to be included under each category.

After completing the Round 1 questionnaire, click **Done**. You should receive a Thank You receipt for your submission. After the submission receipt displays, another **Done** button will also appear. Please click this button as well to finalize your submission.

1. ****Category** The Adult Learner in 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

2. ****Component****Students enrolled in an online 3D modeling course should take the initiative to acquire and construct new knowledge.

Keep Reject Modify
(Textbox provided for modifications)

3. ****Component****Students enrolled in an online 3D modeling course should establish individual learning goals for online learning.

Keep Reject Modify
(Textbox provided for modifications)

4. *Additional Responses (Please type new components for this category here.)*

5. ****Category** Learner-Centered Instructional Framework for 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

6. ****Component****Learner-centered framework is based on two ideas-the individual and the learning.

Keep Reject Modify
(Textbox provided for modifications)

7. **Component** In an online 3D modeling course, individual learner experiences should be valued.

Keep Reject Modify
(Textbox provided for modifications)

8. *Additional Responses (Please type new components for this category here.)*

9. **Category** **Knowledge-Centered Instructional Frameworks for 3D Modeling Courses.**

Keep Reject Modify
(Textbox provided for modifications)

10. **Component** The construction of new knowledge structures in a 3D online modeling courses is essential to its success.

Keep Reject Modify
(Textbox provided for modifications)

11. **Component** Students enrolled in an online 3D modeling course should find meaning and relevance in their coursework.

Keep Reject Modify
(Textbox provided for modifications)

12. *Additional Responses (Please type new components for this category here.)*

13. **Category** **Community-Centered Instructional Frameworks for 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

14. **Component** Establishing communities of practice through course activities is essential in an online 3D modeling course.

Keep Reject Modify
(Textbox provided for modifications)

15. **Component** 3D modeling courses taught online should promote creative and critical thinking whether independently and collaboratively.

Keep Reject Modify
(Textbox provided for modifications)

16. *Additional Responses (Please type new components for this category here.)*

17. **Category** **Assessment-Centered Instructional Frameworks for 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

18. **Component** In an introductory 3D modeling course assessments should be considered as part of the instructional process and should be used to adjust teaching practices while instruction is taking place.

Keep Reject Modify
(Textbox provided for modifications)

19. **Component** In an online introductory 3D modeling course assessments should act as an accountability measurement and be given periodically in the form of quizzes and tests.

Keep Reject Modify
(Textbox provided for modifications)

20. *Additional Responses (Please type new components for this category here.)*

21. **Category** **Instructional Design for 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

22. **Component** 3D modeling content delivered online is developed from course objectives and utilizes appropriate technologies.

Keep Reject Modify
(Textbox provided for modifications)

23. **Component** 3D modeling courses taught online should continue use of offline sketching activities.

Keep Reject Modify
(Textbox provided for modifications)

24. *Additional Responses (Please type new components for this category here.)*

25. **Category** **Drawing & Modeling Content for 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

26. **Component** Online 3D modeling courses should include 3D visualization and modeling techniques.

Keep Reject Modify
(Textbox provided for modifications)

27. **Component** Online 3D modeling courses should provide instruction on traditional topics such as dimensioning.

Keep Reject Modify
(Textbox provided for modifications)

28. *Additional Responses (Please type new components for this category here.)*

29. **Category** **Identifying Interactions for 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

30. **Component** Interactions allow learners to interface with the environment in which the learning takes place.

Keep Reject Modify
(Textbox provided for modifications)

31. **Component** Learner interactions in online 3D modeling courses should include interactions with a Learning Management Systems, content via the web, and/or Web 2.0 technologies.

Keep Reject Modify
(Textbox provided for modifications)

32. *Additional Responses (Please type new components for this category here.)*

33. **Category** **Interactive Technologies for 3D Modeling Courses**

Keep Reject Modify
(Textbox provided for modifications)

34. **Component** Online 3D modeling courses should use application sharing through synchronous communications to demonstrate design softwares such as SolidWorks.

Keep Reject Modify
(Textbox provided for modifications)

35. **Component** 3D modeling courses taught online should use demonstration videos and voice-over PowerPoints.

Keep Reject Modify
(Textbox provided for modifications)

36. *Additional Responses (Please type new components for this category here.)*

APPENDIX D

Email Notification to Review Panel for Round 2

Email Notification to Expert Panel for Round 2

Gentle Reminder Email to Expert Panel for Round 2

Revised Gentle Reminder Email Notification to Expert Panel for
Round 2

Round 2 Questionnaire

Table A. Statistical Means and Standard Deviations for Round 2
Components

Table B. Cronbach's Alpha Analysis, Learner-Centeredness Initial
Components

Table C. Stepwise Deletion 1 of Learner-Centeredness Components,
Results from Removing Component 9

Table D. Stepwise Deletion 2 of Learner-Centeredness Components,
Results from Removing Component 3

Table E. Cronbach's Alpha Analysis, Drawing & Modeling Content
Initial Components

Table F. Stepwise Deletion 1 of Drawing & Modeling Content, Results
from Removing Component 33

Note: Email Notification to Review Panel for Round 2

Dear Educators,

Thank you again for agreeing to serve as a reviewer for this doctoral study. Attached is a pdf of the results from the Round 1 Questionnaire. Instructions about your responsibility as a reviewer for the Round 2 Questionnaire are included in the document. Please review the attached document before viewing the web-based Round 2 Questionnaire.

After reviewing both the attached pdf and the web-based questionnaire, **please submit your modifications for the Round 2 Questionnaire by midnight, Friday, May 28, 2010**. When reviewing the completed, web-based questionnaire you may use the 'Type Additional Components Here' text box to submit your feedback OR if you believe the completed web-based questionnaire does not require modification a response is not required. You may also email any feedback you would like to submit directly to me. Below is the link to the Round 2 questionnaire.

http://www.surveymonkey.com/s/3DMOG_ROUND2

Thank you again for your time, expertise, and participation in this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Email Notification to Expert Panel for Round 2

Dear Educators,

The Round 2 Questionnaire has been approved by the review panel. The questionnaire is now open to collect your responses. Please visit the link below for instructions. Responses must be submitted by Wednesday, June 16, 2010 by midnight. The questionnaire only requires 10-15 minutes of your time.

http://www.surveymonkey.com/s/3DMOG_ROUND2

Thank you again for your time, expertise, and participation in this study. Your responses are vital to the success of this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Gentle Reminder Email Notification to Expert Panel for Round 2

Dear Expert Panel Members,

Thank you for submitting your responses to the Round 2 questionnaire that was made accessible on June 2, 2010. Many of you have yet to respond, but there is still time to do so. As an expert panelist your responses are vital for the success of this research. **If you have not yet had a chance to respond, please complete and submit your responses by Wednesday, June 16, 2010. The survey will close on June 16 at midnight. Any responses submitted after that time will not be accepted by the survey collector.**

http://www.surveymonkey.com/s/3DMOG_Round2

I know that you all have many other obligations, so please know that I am grateful for your help and willingness to participate in this study. If you have any questions or concerns, please feel free to email me. Again, many thanks.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Revised Gentle Reminder Email Notification to Expert Panel for Round 2

Dear Expert Panel Members,

The reminder you received earlier contained a glitch in the web link for the Round 2 survey. Although I am not sure why, the issue has been corrected. The link below should allow you access to the survey. Thank you.

http://www.surveymonkey.com/s/3DMOG_ROUND2

Kathleen Mapson

Thank you for submitting your responses to the Round 2 questionnaire that was made accessible on June 2, 2010. Many of you have yet to respond, but there is still time to do so. As an expert panelist your responses are vital for the success of this research. **If you have not yet had a chance to respond, please complete and submit your responses by Wednesday, June 16, 2010. The survey will close on June 16 at midnight. Any responses submitted after that time will not be accepted by the survey collector.**

http://www.surveymonkey.com/s/3DMOG_ROUND2

I know that you all have many other obligations, so please know that I am grateful for your help and willingness to participate in this study. If you have any questions or concerns, please feel free to email me. Again, many thanks.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Round 2 Questionnaire

Rating, Ranking, and Additional Components

Instructions: Rating

Please RATE each of the following components using the Likert scale below. Both the revised components and new components are the results from the Round 1 Questionnaire.

Ratings for this round are based on appropriateness (and consideration) when developing an online introductory 3D modeling course. The Likert scale to be used for rating the components is as follows:

1=Strongly Agree that this component should be considered/included when developing online introductory 3D modeling courses.

2=Agree that this component should be considered/included when developing online introductory 3D modeling courses.

3=Neutral position that this component should be considered/included when developing online introductory 3D modeling courses.

4=Disagree that this component should be considered/included when developing online introductory 3D modeling courses.

5=Strongly Disagree that this component should be considered/included when developing online introductory 3D modeling courses.

Instructions: Ranking

Next, RANK each component WITHIN it's category, starting with (1) being the most important component WITHIN it's category (1 most important, 2, 3, 4...). It is extremely important for this round that you identify the most important to least important components for EACH category. Please make sure that all components for each category receive a ranking.

Instructions: Additional Components

Please try to include additional components to consider/include. Although this round requires you to rate and rank components currently listed, the other goal is for you to provide additional components that should be considered/included when developing 3D modeling for online teaching and learning.

Instructions: Submission

After completing the Round 2 questionnaire, click Done. You should receive a Thank You receipt for your submission. After the submission receipt displays, another Done button will

also appear. Please click this button as well to finalize your submission. Please be sure to submit your responses within two weeks from the date the researcher has notified you of the this survey's availability.

****Category****

The Adult Learner

1. ****Revised Component****

Students enrolled in an online 3D modeling course should take the initiative to acquire knowledge through identifying, selecting, or constructing a learning pathway from a series of predefined modules guided by the instructor.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

2. ****Revised Component****

Students enrolled in an online 3D modeling course should have an understanding of course standards and objectives in order to establish individual learning goals that are aligned with the course.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5- Strongly Disagree

3. ****New Component****

The prior knowledge of students enrolled in an online 3D modeling course is impacted by work and life obligations.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

4. ****New Component****

Students need to be self motivated and disciplined when taking 3D modeling online courses.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

5. TEXTBOX--Type additional components here.

****Category****

Learner-Centered Instructional Framework

6. ****Revised Component****

Online 3D modeling courses should be based on the idea that the learner will be actively engaged in the learning process.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

7. ****No Suggested Modifications****

An online 3D modeling course using a learner-centered approach should value individual

learner experiences.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

8. TEXTBOX--Type additional components here.

****Category****

Knowledge-Centered Instructional Framework

9. ****Revised Component****

The construction of new knowledge structures is important in an online 3D modeling course.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

10. ****Revised Component****

Students enrolled in an online 3D modeling course should understand, and find meaning and relevance in the application of their coursework.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

11. TEXTBOX--Type additional components here.

****Category****

Community-Centered Instructional Frameworks

12. ****Revised Component****

Ensuring sufficient participation through course activities, group discussions, and collaborative projects establishes a sense of community and is essential in an online 3D modeling course.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

13. ****No Suggested Modifications****

3D modeling courses taught online should promote creative and critical thinking whether independently or collaboratively.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

14. ****New Component****3D modeling courses taught online should promote community-constructed knowledge.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

15. TEXTBOX--Type additional components here.

****Category****

Assessment-Centered Instructional Frameworks

16. ****Revised Component****

In an introductory 3D modeling course, assessments should be considered as part of the instructional process.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

17. ****Revised Component****

In an online introductory 3D modeling course, assessments should serve as an accountability measurement and be given periodically in the form in which the learning has been obtained.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

18. ****New Component****

In an online 3D modeling course, assessments should developed from project-based learning activities.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

19. ****New Component****

In an online 3D modeling course, formative assessments that provide specific guidelines to correct errors should be context dependent and should be used to provide periodic feedback to learners

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

20. TEXTBOX--Type additional components here.

****Category****

Instructional Design

21. ****Revised Component****

3D modeling content delivered online is derived from course objectives and competencies.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

22. ****Revised Component****

Sketching activities should be used as a supplement when teaching 3D modeling online.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

23. ****Revised Component****

3D modeling courses taught online should use demonstration videos and voice-over PowerPoints as an instructional option.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

24. ****New Component****

3D modeling courses taught online should have a clear feedback path established that allows students to communicate with the instructor/professor.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

25. ****New Component****

Instructional design for 3D modeling courses should include collaborative project work for small teams/groups.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

26. ****New Component****

The 3D modeling online course should be interactive and capable of being tailored to the user.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

27. ****New Component****

Online 3D modeling courses should provide adequate links, readings, and online discussions.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

28. TEXTBOX--Type additional components here.

****Category****

Drawing & Modeling Content

29. ****Revised Component****

Visualization for 3D models should be taught in an online 3D modeling course.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

30. ****Revised Component****

The scope and context of 3D models in a modeling course should determine if traditional topics such as dimensioning will be taught.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

31. ****New Component****

Process flows should be taught in an online 3D modeling course.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

32. ****New Component****

The modeling thought process should be included in instruction for online 3D modeling courses.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

33. ****New Component****

Drawing and modeling content for online 3D modeling courses should include geometry constructions and relationships.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

34. ****New Component****

3D modeling courses taught online should demonstrate the application of 3D modeling in practical applications of design and manufacturing.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

35. ****New Component****

3D modeling courses should include modeling theory and strategies.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

36. ****New Component****

Online 3D modeling courses should demonstrate software specific techniques.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

37. ****New Component****

Online 3D modeling courses should provide instruction about the different types of 3D modeling (parametric modeling, constraint based modeling, boundary representation and wireframe/surface modeling, and constructive solid geometry modeling).

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

38. ****New Component****

Online 3D modeling courses should introduce geometric dimensioning and tolerancing to teach the concepts of using physical features for datums and bonus tolerance.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

39. ****New Component****

3D modeling courses taught online should provide instruction on troubleshooting and correcting common modeling errors.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

40. ****New Component****

3D modeling courses taught online should provide historical information and new directions for the 3D modeling industry.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

41. ****New Component****

3D modeling concepts should include real world problem solving related to codes and standards, strength of materials, and common manufacturing practices.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

42. ****New Component****

CAD programs containing specific design components or "tool boxes" should be clearly identified and explained in online instruction.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

43. ****New Component****

Drawing standards should be included in online 3D modeling courses.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

44. ****New Component****

Instruction on multiviews and isometric assembly views-manually and using software-should be included in online instruction.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

45. TEXTBOX--Type additional components here.

****Category****

Identifying Interactions

46. ****Revised Component****

Interactions in the environment where learning takes place is important when solving real world issues.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

47. ****No Suggested Modifications****

Learners interactions in online 3D modeling courses include interactions with a Learning Management System, content via the web, or Web 2.0 technologies.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

48. ****New Component****

Learning interactions in online 3D modeling courses should include peer-to-peer interactions.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

49. ****New Component****

Learning interactions in online 3D modeling courses should include communications with the course professor and other instructors.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

50. ****New Component****

Collaborative discussions and demonstrations amongst class members and/or assigned groups should be utilized for self-teaching amongst peers.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

51. TEXTBOX--Type additional components here.

****Category****

Interactive Technologies

52. ****Revised Component****

Application sharing should be used to demonstrate design software.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

53. ****New Component****

3D modeling courses taught online should include interactive exercises that react to student input and provide constructive, context-sensitive feedback to the student.

1-Strongly Agree 2-Agree 3-Neutral 4-Disagree 5-Strongly Disagree

54. TEXTBOX--Type additional components here.

Table A

Statistical Means and Standard Deviations for Round 2 Components

The Adult Learner (category)

Mean	SD	Component
2.08	0.90	Students enrolled in an online 3D modeling course should take the initiative to acquire knowledge through identifying, selecting, or constructing a learning pathway from a series of predefined modules guided by the instructor.
1.75	0.75	Students enrolled in an online 3D modeling course should have an understanding of course standards and objectives in order to establish individual learning goals that are aligned with the course.
1.75	0.75	The prior knowledge of students enrolled in an online 3D modeling course is impacted by work and life obligations.
1.25	0.45	Students need to be self motivated and disciplined when taking 3D modeling online courses.
1.71	0.34	Total Mean & Standard Deviation

Learner-Centered Instructional Framework (category)

Mean	SD	Component
1.25	0.45	Online 3D modeling courses should be based on the idea that the learner will be actively engaged in the learning process.
1.75	0.62	An online 3D modeling course using a learner-centered approach should value individual learner experiences.
1.50	0.35	Total Mean & Standard Deviation

Table A (continued)

Knowledge-Centered Instructional Framework (category)

Mean	SD	Component
2.25	0.75	The construction of new knowledge structures is important in an online 3D modeling course.
1.42	0.51	Students enrolled in an online 3D modeling course should understand, and find meaning and relevance in the application of their coursework.
1.84	0.59	Total Mean & Standard Deviation

Community-Centered Instructional Framework (category)

Mean	SD	Component
2.08	1.17	Ensuring sufficient participation through course activities, group discussions, and collaborative projects establishes a sense of community and is essential in an online 3D modeling course.
1.67	0.65	3D modeling courses taught online should promote creative and critical thinking whether independently or collaboratively.
2.50	0.80	3D modeling courses taught online should promote community-constructed knowledge.
2.08	0.42	Total Mean & Standard Deviation

Assessment-Centered Instructional Framework (category)

Mean	SD	Component
1.50	0.80	In an introductory 3D modeling course, assessments should be considered as part of the instructional process.

Table A (continued)

1.75	0.75	In an introductory 3D modeling course, assessments should serve as an accountability measurement and be given periodically in the form in which the learning has been obtained.
2.00	0.74	In an online 3D modeling course, assessments should developed from project-based learning.
1.67	0.78	In an online 3D modeling course, formative assessments that provide specific guidance to correct errors should be context dependent and should be used to provide periodic feedback to learners.
1.77	0.20	Total Mean & Standard Deviation

Instructional Design (category)

Mean	SD	Component
1.25	0.45	3D modeling content delivered online is derived from course objectives and competencies.
1.67	0.78	Sketching activities should be used as a supplement when teaching 3D modeling online.
1.62	0.35	Total Mean & Standard Deviation
2.08	0.79	3D modeling courses taught online should use demonstration videos and voice-over PowerPoints as an instructional option.
1.33	0.49	3D modeling courses taught online should have a clear feedback path established that allows students to communicate with the instructor/professor.
2.25	1.055	Instructional design for 3D modeling courses should include collaborative project work for small teams/groups.
2.33	0.89	The 3D modeling online course should be interactive and capable of being tailored to the user.

Table A (continued)

1.67	0.49	Online 3D modeling courses should provide adequate links, readings, and online discussions.
1.88	0.40	Total Mean & Standard Deviation

Drawing & Modeling Content (category)

Mean	SD	Component
1.50	0.67	Visualization for 3D models should be taught in an online 3D modeling course.
2.92	1.24	The scope and context of 3D models in a modeling course should determine if traditional topics such as dimensioning will be taught.
2.50	0.80	Process flows should be taught in an online 3D modeling course.
1.50	0.67	The modeling thought process should be included in instruction for online 3D modeling courses.
1.92	0.67	Drawing and modeling content for online 3D modeling courses should include geometry constructions and relationships.
1.50	0.52	3D modeling courses taught online should demonstrate the application of 3D modeling in practical applications of design and manufacturing.
1.30	0.49	3D modeling courses should include modeling theory and strategies.
2.17	0.39	Online 3D modeling courses should demonstrate software specific techniques.
1.91	0.54	Total Mean & Standard Deviation
1.83	0.94	Online 3D modeling courses should provide instruction about the different types of 3D modeling (parametric modeling, constraint based modeling, boundary representation and wireframe/surface modeling, and constructive solid geometry modeling).

Table A (continued)

2.83	0.94	Online 3D modeling courses should introduce geometric dimensioning and tolerancing to teach the concepts of using physical features for datums and bonus tolerance.
1.75	0.62	3D modeling courses taught online should provide instruction on troubleshooting and correcting common modeling errors.
2.92	0.51	3D modeling courses taught online should provide historical information and new directions for the 3D modeling industry.
2.50	0.67	3D modeling concepts should include real world problem solving related to codes and standards, strength of materials, and common manufacturing practices.
2.33	0.65	CAD programs containing specific design components or "tool boxes" should be clearly identified and explained in online instruction.
2.33	0.98	Drawing standards should be included in online 3D modeling courses.
2.50	1.31	Instruction on multiviews and isometric assembly views-manually and using software-should be included in online instruction.
2.34	0.42	Total Mean & Standard Deviation

Identifying Interactions (category)

Mean	SD	Component
2.08	0.67	Interactions in the environment where learning takes place is important when solving real world issues.
2.50	0.90	Learners interactions in online 3D modeling courses include interactions with a Learning Management System, content via the web, or Web 2.0 technologies.

Table A (continued)

2.29	0.30	Total Mean & Standard Deviation
1.92	0.67	Learning interactions in online 3D modeling courses should include peer-to-peer interactions.
1.25	0.45	Learning interactions in online 3D modeling courses should include communications with the course professor and other instructors.
2.17	0.58	Collaborative discussions and demonstrations amongst class members and/or assigned groups should be utilized for self-teaching amongst peers.
2.78	0.48	Total Mean & Standard Deviation

Interactive Technologies (category)

Mean	SD	Component
2.25	0.84	Application sharing should be used to demonstrate design software.
1.67	0.78	3D modeling courses taught online should include interactive exercises that react to student input and provide constructive, context-sensitive feedback to the student.
1.96	0.41	Total Mean & Standard Deviation

Table B

Cronbach's Alpha Analysis, Learner-Centeredness Initial Components

	N	Mean	Variance	SD
Scale Statistics	8	13.58	7.720	2.778
Reliability Coefficient	$\alpha = 0.601$			

Item-Total Statistics	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C1	11.50	4.455	.646	.421
C2	11.83	5.424	.492	.502
C3	11.83	6.697	.117	.628
C4	12.33	6.606	.391	.557
C6	12.33	7.152	.150	.603
C7	11.75	6.205	.411	.541
C9	11.42	6.992	.007	.672
C10	12.08	6.447	.377	.554

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C5 & C8 were not included in analysis. They were text fields in the Round 2 questionnaire.

Table C

*Stepwise Deletion 1 of Learner-Centeredness Components
Results from Removing Component 9*

	N	Mean	Variance	SD
Scale Statistics	7	11.42	6.992	2.644
Reliability Coefficient	$\alpha = 0.672$			
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C1	9.33	3.879	.649	.534
C2	9.67	4.970	.433	.622
C3	9.67	5.697	.202	.696
C4	10.17	5.788	.460	.628
C6	10.17	6.152	.284	.662
C7	9.58	5.720	.340	.648
C9	Eliminated 1 st	--	--	--
C10	9.92	5.720	.400	.636

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C5 & C8 were not included in analysis. They were text fields in the Round 2 questionnaire.

Note: C9 was not included in this analysis. It was eliminated in the first stepwise deletion.

Table D

*Stepwise Deletion 2 of Learner-Centeredness Components
Results from Removing Component 3*

	N	Mean	Variance	SD
Scale Statistics	6	9.67	5.697	2.387
Reliability Coefficient	$\alpha = 0.696$			
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C1	7.58	2.629	.773	.497
C2	7.92	3.902	.412	.665
C3	Eliminated 2 nd	--	--	--
C4	8.42	4.629	.444	.659
C6	8.42	5.174	.155	.721
C7	7.83	4.515	.346	.680
C9	Eliminated 1 st	--	--	--
C10	8.17	4.333	.502	.638

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C5 & C8 were not included in analysis. They were text fields in the Round 2 questionnaire.

Note: C9 was not included in this analysis. It was eliminated in the first stepwise deletion.

Note: C3 was not included in this analysis. It was eliminated in the second stepwise deletion.

Table E

Cronbach's Alpha Analysis, Drawing & Modeling Content Initial Components

	N	Mean	Variance	SD
Scale Statistics	16	35.00	28.545	5.343
Reliability Coefficient	$\alpha = 0.648$			
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C29	33.50	23.909	.634	.589
C30	32.08	26.265	.058	.677
C31	32.50	25.727	.270	.631
C32	33.50	25.727	.346	.623
C33	33.08	29.720	-.222	.683
C34	33.00	22.727	.475	.594
C35	33.67	28.424	-.023	.658
C36	32.83	27.242	.283	.636
C37	33.17	24.152	.382	.613
C38	32.17	25.424	.237	.636
C39	33.25	26.932	.190	.641
C40	32.08	26.992	.241	.637

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Table E (continued)

Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C41	32.50	27.909	.026	.658
C42	32.50	23.727	.538	.594
C43	32.67	24.970	.265	.632
C44	32.50	21.000	.483	.588

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Table F

*Stepwise Deletion 1 of Drawing & Modeling Content Components
Results from Removing Component 33*

	N	Mean	Variance	SD
Scale Statistics	15	33.08	29.720	5.452
Reliability Coefficient	$\alpha = 0.683$			
Item-Total Statistics				
	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C29	31.58	24.811	.663	.629
C30	30.17	26.697	.116	.705
C31	30.58	27.174	.230	.676
C32	31.58	26.811	.352	.663
C33	Eliminated 1 st	--	--	--
C34	31.08	24.447	.405	.651
C35	31.75	29.841	-.068	.697
C36	30.92	28.265	.315	.673
C37	31.25	24.932	.418	.650

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C33 was not included in this analysis. It was eliminated in the first stepwise deletion.

Table F (continued)

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
C38	30.25	26.568	.235	.676
C39	31.33	28.424	.137	.684
C40	30.17	27.970	.273	.673
C41	30.58	24.629	-.012	.699
C42	30.58	24.629	.563	.634
C43	30.75	25.841	.291	.669
C44	30.58	21.356	.546	.621

Note: Component numbers (ex. C1) align with the Round 2 questionnaire component numbers.

Note: C33 was not included in this analysis. It was eliminated in the first stepwise deletion.

APPENDIX E

Email Notification to Review Panel for Round 3

Email Notification to Expert Panel for Round 3

Gentle Reminder Email Notification to Expert Panel for Round 3

Round 3 Questionnaire

Note: Email Notification to Review Panel for Round 3

Dear Educators,

Thank you again for agreeing to serve as a reviewer for this doctoral study. This is the final round for this study. I sincerely appreciate the contributions you all have made to make this study a success.

Attached is a pdf of the results from the Round 2 Questionnaire. Instructions about your responsibility as a reviewer for the Round 3 Questionnaire are included in the document. Please review the attached document before viewing the web-based Round 3 Questionnaire.

After reviewing both the attached pdf and the web-based questionnaire, **please submit your modifications for the Round 3 Questionnaire by midnight, Tuesday, November 23, 2010**. When reviewing the completed web-based questionnaire, you may submit your feedback by emailing me directly. If you believe the completed web-based questionnaire does not require modification a response is not required. Below is the link to the Round 3 questionnaire.

http://www.surveymonkey.com/s/3DMOG_ROUND3

Thank you again for your time, expertise, and participation in this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Email Notification to Expert Panel for Round 3

Dear Educators,

I hope that you all are doing well!

The final round of this study has been approved by the review panel. The categories and components for this round are based on the responses analyzed and compiled from the Round 2 questionnaire. The Round 3 Questionnaire is now open to collect your responses. Please visit the link below for instructions. Responses must be submitted by Wednesday, December 8, 2010 by midnight. The questionnaire only requires 15-20 minutes of your time. Note: If you did not participate in Round 2, you MAY STILL participate in Round 3.

http://www.surveymonkey.com/s/3DMOG_ROUND3

Thank you again for your time, expertise, and participation in this study. Your responses are vital to the success of this study. If you have any questions please feel free to contact me by email.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Note: Gentle Reminder Email Notification to Expert Panel for Round 3

Dear Educators,

Thank you for submitting your responses to the Round 3 questionnaire that was made accessible on December 1, 2010. As an expert panelist your responses are vital for the success of this research. If you have not yet had a chance to respond, please complete and submit your responses by Wednesday, December 8, 2010. The survey will close on December 8 at midnight. Any responses submitted after that time will not be accepted by the survey collector.

http://www.surveymonkey.com/s/3DMOG_ROUND3

I know that you all have many other obligations, so please know that I am grateful for your help and willingness to participate in this study. If you have any questions or concerns, please feel free to email me. Again, many thanks.

Kindest Regards,
Kathleen H. Mapson
Doctoral Researcher
Technology Education
kdharrel@ncsu.edu

Dr. Aaron C. Clark, Chair
Dr. Jeremy V. Ernst, Co-Chair
North Carolina State University

Round 3 Questionnaire: The Final Round

Listed below are the instructions for completing the final round of questioning for this study. Participation only requires 15-20 minutes of your time. Again, this study is designed to determine the best practices for designing online learning environments for introductory 3D modeling curricula.

Instructions: Demographic Information

Since the start of this research study changes to your demographic information may have occurred. Considering this, I would like for you to respond to a few demographic questions. If your information has not changed, I would still appreciate your responses to the demographic questions for final analysis. After completing your Demographics Questionnaire, please complete the final round of questions for this study.

Instructions: Round 3 Questionnaire

The information presented in the Round 3 Questionnaire contains the revised categories and components collected and analyzed from Round 2 participant responses. Again, the components presented are to be considered or used when developing an introductory 3D modeling course for online teaching and learning.

For the final round of this Delphi study, you are to Accept or Reject the components that you believe should (or should not) be retained for the best practices inventory.

Instructions: Submissions

After completing the final round of questions please click Done. You should receive a Thank You receipt for your submission. After the submission receipt displays, another Done button will also appear. Please click this button as well to finalize your submission. Please be sure to submit your responses within one week from the date the researcher has notified you of the this survey's availability.

Demographics Survey for Round 3

1. Please provide your email address. All participants remain confidential and anonymous to one another. This information will be used to contact you with the results of the study.
(textbox)
2. Which title most accurately describes your position? *(If other, please type response in the textbox provided)*
 - a. Engineering educator
 - b. Engineering graphics educator
 - c. Technology educator
 - d. Other
**Textbox for additional response
3. What is the highest degree obtained as of August 2010?
 - a. BS/BA
 - b. MA/MS/MEd
 - c. EdD/PhD
4. List the major area for each degree you hold. *(Please indicate the discipline and name of University your degree was awarded in the textbox provided)*
 - a. BS/BA **Textbox for additional response
 - b. MS/Med **Textbox for additional response
 - c. EdD/PhD **Textbox for additional response
5. How many years of experience do you have in teaching engineering graphics courses?
 - a. 1 year or less
 - b. 1-2 years
 - c. 2-3 years
 - d. 3 years or more
6. How many years of experience do you have in teaching 3D modeling courses?
 - a. 1 year or less
 - b. 1-2 years
 - c. 2-3 years
 - d. 3 years or more
 - e. None
7. Are you currently teaching, developing, or implementing any type of engineering graphics course for hybrid or fully online instruction? If so, provide the name of the course(s) and a very brief description in the textbox provided.
 - a. Yes

b. No

**Textbox for additional response

8. What is your experience with course development for engineering graphics education and/or 3D modeling?
- a. 1 year or less
 - b. 1-2 years
 - c. 2-3 years
 - d. 3 years or more
 - e. None
9. Have you ever taught or developed a fully online course? (If "yes", select your years of experience from one of the answer choices below.)
- a. 1 year or less
 - b. 1-2 years
 - c. 2-3 years
 - d. 3 years or more
 - e. None
10. Have you ever taught or developed a hybrid or blended course? (If "yes", select your years of experience from one of the answer choices below.)
- a. 1 year or less
 - b. 1-2 years
 - c. 2-3 years
 - d. 3 years or more
 - e. None
11. Have you received any professional development training within the last two years for hybrid (blended) or online course development? (Please type additional response in the textbox provided.)
- a. Yes
 - b. No
- **Textbox for additional response

Instructions: Round 3 Questionnaire

The information presented in the Round 3 Questionnaire contains the revised categories and components collected and analyzed from Round 2 participant responses. Again, the components presented are to be considered or used when developing an introductory 3D modeling course for online teaching and learning.

For the final round of this Delphi study, you are to Accept or Reject the components that you believe should (or should not) be retained for the best practices inventory.

Instructions: Submissions

After completing this round please click Done. You should receive a Thank You receipt for your submission. After the submission receipt displays, another Done button will also appear. Please click this button as well to finalize your submission. Please be sure to submit your responses within one week from the date the researcher has notified you of the this survey's availability.

Note: An asterisk denotes the modification of a component based on participant responses from Round 2.

Learner-Centeredness (Revised Category)

1. Students should take the initiative to acquire knowledge through identifying, selecting, or constructing a learning pathway from a series of predefined modules guided by the instructor.
-Accept -Reject

2. Students should have an understanding of course standards and objectives in order to establish individual learning goals that are aligned with the course.
-Accept -Reject

3. Students need to be self-motivated and disciplined when taking 3D modeling courses online.
-Accept -Reject

4. Individual learner experiences should be valued and considered in online 3D modeling courses.
-Accept -Reject

5. Students should understand, and find meaning and relevance in the application of their coursework.
-Accept -Reject

Course Design (*Revised Category*)

6. Ensuring sufficient participation through course activities, group discussions, and collaborative projects is essential in a hybrid or fully online modeling course.

-Accept -Reject

7. Online modeling courses should promote creative and critical thinking through independent and/or collaborative work.

-Accept -Reject

8. Information constructed from the community of learners (course participants) should be promoted and included in instruction or serve as supplemental material for online modeling courses. *

-Accept -Reject

9. Assessments should be considered as part of the instructional design process when developing online instruction.

-Accept -Reject

10. Assessments should periodically be given in the form in which the learning has been obtained.*

-Accept -Reject

11. Assessments should be developed from all course activities including project-based learning activities.*

-Accept -Reject

12. Assessments that provide specific guidance to correct errors should be context dependent and used to provide periodic feedback to learners.

-Accept -Reject

13. 3D modeling content delivered online should derive from course objectives and course competencies.

-Accept -Reject

14. Sketching activities should be used as a supplement when teaching 3D modeling online.

-Accept -Reject

15. Content delivered asynchronously should include multiple methods of delivery to meet individual learning styles. *

-Accept -Reject

16. Online modeling courses should have a clear feedback path established that allows students to communicate with the instructor/professor.
-Accept -Reject
17. Online modeling courses should support and provide collaborative project work for small teams/groups.*
-Accept -Reject
18. The online 3D modeling environment should provide students with the capability of tailoring or customizing their learning experience.*
-Accept -Reject
19. Adequate internal and external resource links, and required and supplemental readings should be included in online learning.*
-Accept -Reject
20. Establishing and encouraging interactions in the online environment is important when addressing and solving real world issues related to 3D modeling.
-Accept -Reject
21. Online interactions with course content include the use of a Learning Management System (LMS).*
-Accept -Reject
22. Peer-to-peer interactions should be fostered and designed into online instruction.
-Accept -Reject
23. Communications with the course professor and other instructors knowledgeable of the subject matter should be encouraged.
-Accept -Reject
24. Collaborative discussions and demonstrations amongst class members and/or assigned groups should be included and utilized for self-teaching amongst peers.
-Accept -Reject
25. Application sharing should be used for live demonstrations of course software.*
-Accept -Reject
26. Interactive exercises that react to student input and provide constructive, context-sensitive feedback to the student should be included in online instruction.
-Accept -Reject

27. Online modeling courses should employ collaborative tools such as wikis to allow learners to discuss, construct, or demonstrate understanding of course topics.*
-Accept -Reject
28. Online modeling courses should utilize discussion boards to pose thoughts/questions, evoke responses, and/or address issues.*
-Accept -Reject
29. Online interactive whiteboards should be used in online modeling courses to facilitate real-time collaborations between learners or between the course instructor and the learners.*
-Accept -Reject
30. Blogs should be included in online modeling courses to document processes, share opinions, provide commentary, and/or personal reflections about course projects, assignments, or questions posed by the instructor.*
-Accept -Reject
31. Live (real-time, synchronous) tools should occasionally be included in online modeling courses to facilitate course presentations, communications, and/or establish a greater sense of personal engagement between the learners and the course instructor.*
-Accept -Reject
32. Social bookmarking tools should be utilized to collectively identify and construct an inventory of online modeling resources/websites.
-Accept -Reject
33. Online interactions include accessing content through a course website.
-Accept -Reject
34. Application sharing should be utilized to assess the student's knowledge of software application.*
-Accept -Reject
35. Real-time applications for the creation of process flows and diagrams should be included in online instruction.*
-Accept -Reject
36. Modeling content delivered asynchronously should include lecture capture videos.*
-Accept -Reject
37. Course content should be displayed using voice-over PowerPoints.
-Accept -Reject

38. Demonstration videos displaying hands-on sketching practices/techniques should be included in online instruction.*

-Accept -Reject

39. Screencasts should be included in online modeling content to visually present recorded step-by-step processes/demonstrations of course software usage.*

-Accept -Reject

40. Online modeling courses should incorporate simulations/animations to demonstrate the internal processes of model building.*

-Accept -Reject

41. Podcasts should be used to provide audible explanations, commentary, and/or reflections on course assignments, course projects, and/or overall student progress.*

-Accept -Reject

Drawing & Modeling Content

42. Visualization for 3D models should be taught in an online modeling course.

-Accept -Reject

43. Process flows should be taught in an online modeling course.

-Accept -Reject

44. The modeling thought process should be included in online instruction.

-Accept -Reject

45. The application of 3D modeling in practical applications of design and manufacturing should be demonstrated.

-Accept -Reject

46. Modeling theory including development strategies should be included in online instruction.*

-Accept -Reject

47. Online modeling courses should demonstrate software specific techniques.

-Accept -Reject

48. Instruction about the different types of 3D modeling (parametric modeling, constraint based modeling, boundary representation and wireframe/surface modeling, and constructive solid geometry modeling) should be included in an online modeling course.

-Accept -Reject

49. Online 3D modeling courses should introduce geometric dimensioning and tolerancing to teach the concepts of using physical features for datums and bonus tolerance.

-Accept -Reject

50. 3D modeling courses taught online should provide instruction on troubleshooting and correcting common modeling errors.

-Accept -Reject

51. Historical information and new directions for the 3D modeling industry should be included in online instruction.

-Accept -Reject

52. 3D modeling concepts should include real-world problem solving related to codes and standards, strength of materials, and common manufacturing practices.

-Accept -Reject

53. CAD programs containing specific design components or "tool boxes" should be clearly identified and explained in online instruction.

-Accept -Reject

54. Drawing standards should be included in online 3D modeling courses.

-Accept -Reject

55. Instruction on multiviews and isometric assembly views-manually and using software-should be included in online instruction.

-Accept -Reject

APPENDIX F

Thank You Notification to Review and Expert Panel Members
Final Inventory of Best Practices

Note: Thank You Notification to Review & Expert Panel

Dear Educators,

I would like to sincerely Thank You all for participating in this doctoral research study. Your sacrifice of time and the sharing of your knowledge and experiences were invaluable to the success of this study. It is my hope that the results of this research study will serve as a blueprint for those that are in the beginning stages of online course development for introductory 3D modeling or comparable engineering graphics courses. This inventory can also be used to assist those that are continuing to develop new and innovative courses or revise existing courses for online teaching and learning.

Attached are the results for this study. I hope that you all will find this inventory of best practices beneficial when developing for online teaching, and that you along with me, believe that it will find it's place in the growing body of literature for Engineering Design Graphics education.

Again, I sincerely Thank You for your participation and I wish you an abundance of success in your future endeavors.

Kindest Regards,
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Note: Final Inventory of Best Practices

Learner-Centeredness

1. Students should take the initiative to acquire knowledge through identifying, selecting, or constructing a learning pathway from a series of predefined modules guided by the instructor.
 2. Students should have an understanding of course standards and objectives in order to establish individual learning goals that are aligned with the course.
 3. Students need to be self-motivated and disciplined when taking 3D modeling courses online.
 4. Individual learner experiences should be valued and considered in online 3D modeling courses.
 5. Students should understand, and find and relevance in the application of their coursework.
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Course Design

6. Ensuring sufficient participation through course activities, group discussions, and collaborative projects is essential in a hybrid or fully online modeling course.
7. Online modeling courses should promote creative and critical thinking through independent and/or collaborative work.
8. Information constructed from the community of learners (course participants) should be promoted and included in instruction or serve as supplemental material for online modeling courses.
9. Assessments should be considered as part of the instructional design process when developing online instruction.
10. Assessments should periodically be given in the form in which the learning has been obtained.
11. Assessments should be developed from all course activities including project-based learning objectives.

12. Assessments that provide specific guidance to correct errors should be context dependent and used to provide periodic feedback to learners.
 13. 3D modeling content delivered online should derive from course objectives and course competencies.
 14. Sketching activities should be used as a supplement when teaching 3D modeling online.
 15. Online modeling courses should have a clear feedback path established that allows students to communicate with the instructor/professor.
 16. Online modeling courses should support and provide collaborative project work for small teams/groups.
 17. Adequate internal and external links, and required and supplemental readings, should be included in online modeling learning.
 18. Establishing and encouraging interactions in the online environment is important when addressing and solving real world issues.
 19. Peer-to-peer interactions should be fostered and designed into hybrid and online instruction.
 20. Communications with the course professor and other instructors knowledgeable of the subject matter should be encouraged.
 21. Collaborative discussions and demonstrations amongst class members and/or assigned groups should be included and utilized for self-teaching amongst peers.
 22. Online interactions include accessing content through a course website.
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Drawing & Modeling Content

23. Visualization for 3D models should be taught in an online modeling course.
24. The modeling thought process should be included in online instruction.
25. The application of 3D modeling in practical applications of design and manufacturing should be demonstrated.
26. Modeling theory and strategies should be included in online instruction.

27. Instruction about the different types of 3D modeling (parametric modeling, constraint based modeling, boundary representation and wireframe/surface modeling, and constructive solid geometry modeling) should be included in an online modeling course.
 28. 3D modeling courses taught online should provide instruction on troubleshooting and correcting common modeling errors.
 29. 3D modeling concepts should include real-world problem solving related to codes and standards, strength of materials, and common manufacturing practices.
 30. CAD programs containing specific design components or "tool boxes" should be clearly identified and explained in online instruction.
 31. Drawing standards should be included in online 3D modeling courses.
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Interactive & Instructional Technologies

32. Online interactions with course content include the use of a *Learning Management System (LMS)*.
33. *Application sharing tools* should be used for live demonstrations of course software.
34. *Interactive exercises* that react to student input and provide constructive, context-sensitive feedback to the student should be included in online instruction.
35. Online modeling courses should utilize *discussion boards* to pose thoughts/questions, evoke responses, and/or address issues.
36. *Application sharing tools* should be utilized to assess the student's knowledge of software application.
37. Modeling content delivered asynchronously should include *lecture capture videos*.
38. *Demonstration videos* displaying hands-on sketching practices or techniques should be included in online instruction.
39. *Screencasts* should be included in online modeling content to visually present recorded step-by-step processes/demonstrations of course software usage.
40. Online modeling courses should incorporate *simulations/animations* to demonstrate the internal processes of model building.