FEASIBILITY STUDY FOR BUILDING INFORMATION MODELING (BIM) EDUCATION AT THE COMMUNITY COLLEGE

A Paper
Submitted to the Graduate Faculty
of the
North Dakota State University
of Agriculture and Applied Science

By

Daniel Vincent Bawinkel

In Partial Fulfillment of the Requirements
for the Degree of
MASTER OF SCIENCE

Major Department:
Construction Management and Engineering

May 2015

Fargo, North Dakota

North Dakota State University
Graduate School

Title

FEASIBILITY STUDY OF BUILDING INFORMATION MODELING (BIM) EDUCATION AT COMMUNITY COLLEGE

By

Daniel Vincent Bawinkel

The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

SUPERVISORY COMMITTEE:

Zhili (Jerry) Gao
Chair

Jongchul Song

Cindy Urness

Approved:

5/13/2015	Yong Bai
Date	Department Chair

ABSTRACT

With limited time and minimal skill sets of students at the community college, it is challenging to integrate new course material into a two-year degree or technical certificate in Building Construction Management while maintaining course structure that the construction and related industries value. This paper studies the feasibility of adding BIM components to the Building Construction Management program at Rock Valley College. Research was conducted through development of a pilot BIM course, surveys of industry and educational professionals, and a review of post-secondary institution. After studying the current state of BIM education in the United States, literature and survey data were analyzed. Analysis suggests that the program can incorporate BIM topics into course material. This inclusion of BIM skills will assist with successful student placement into the construction industry. The regional construction market is ready to embrace BIM technology. Study limitations are further discussed in the paper.

Keywords: Community college, BIM education, Curriculum integration, Construction management

ACKNOWLEDGEMENTS

I would like to thank all who have assisted and supported me in completing the work presented in this paper. I appreciate Dr. Zhili (Jerry) Gao giving the latitude to pursue this research topic considering it's deviation from tradition mainstream projects. His assembly of the committee and patience through the process has been appreciated. I would also like to thank the administration, and staff at Rock Valley College for allowing me to explore new ideas in curriculum for the betterment of the students and the community the college serves. Debby, you're the greatest. I appreciate all those professionals from the construction industry, the A/E community, and sister institutions that have offered input and shared their wisdom with me during this process. Thank you to the additional members of my graduate committee, Dr. Jongchul Song, and Dr. Cindy Urness for taking time away from your schedule to review my presentation. To all my students who had to listen to my trials and tribulations of being a graduate student at the age of fifty. Thanks for putting up with me. Most importantly, I would like to thank my wife and son, who have gone without a husband and father more times than desired during this journey in earning a graduate degree, thank you.

DEDICATION

To all who are not content with the knowledge they have, develop a passion to ask the next question. - Dan

TABLE OF CONTENTS

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

LIST OF ABBREVIATIONS

3D	…….	Three Dimensional
A.A.S.	…….	Associate in Applied Science
ABET	…….	Accreditation Board for Engineering and Technology
ACCE	…….	American Council for Construction Education
ACGDD	…….	Architectural Computer Generated Drafting and Design
AE	…….	Architecture, Engineering
AEC	…….	Architecture, Engineering, Construction
BCM	…….	Building Construction Management
BIM	…….	Building Information Modeling
CAD	…….	Computer Aided Drafting or Design
CAST	……..	Center for Applied Special Technology
CM&E	…….	Construction Management & Engineering
CMS	…….	Content Management System
CSU	…….	Colorado State University
CTE	…….	Career and Technical Education
GSA	…….	Government Services Administration

HVAC	…….	Heating Ventilation & Air Conditioning
ICCB	…….	Illinois Community College Board
IDOT	…….	Illinois Department of Transportation
IPD	…….	Integrated Project Delivery
IRB	…….	Institutional Review Board
MEP	…….	Mechanical, Electrical, Plumbing
NDSU	…….	North Dakota State University
NIBS	…….	National Institute of Building Sciences
PTAC	…….	Procurement Technical Assistance Center
RFI	…….	Request for Information
RVC	…….	Rock Valley College
SLO	…….	Student Learning Outcomes
SLD	.....	Structured Discovery Learning
SLDS	…….	Structured Discovery Learning Strategy
UDL	…….	Universal Design for Learning
VDC	…….	Virtual Design and Construction
WKU	…….	Western Kentucky University

1. INTRODUCTION

1.1. Background

The success of a Career and Technical Education (CTE) program at the community college level hinges on three principal outcomes (Bawinkel, 2013). The first is job placement for the student earning an Associate in Applied Science degree; the second is establishing a skill set that leads to career advancement for the student earning a certificate; and the third is the students' ability to transfer credits to a four-year institution. A program's Academic Chair's responsibility is to ensure that the three above principles are met in a CTE program. One such program is the Building Construction Management (BCM) program at Rock Valley College, in Rockford, Illinois.

While conducting a lengthy Building Construction Management program review for both the College and the Higher Learning Commission as part of the institution's accreditation review, it became obvious that steps previously taken to bolster the architectural drafting and design courses were not adequate for the student to achieve meaningful student learning outcomes. Several reasons for this diminished success can be attributed to a depressed regional construction market place, competition with bachelor degree candidates, and out dated course development and instruction. The instructors who serve the Building Construction Management program at Rock Valley College (RVC) cannot control construction processes in the area; nor does the College offer a bachelor's degree. However, the quality and content of instruction, particularly the inclusion of competitive emerging technologies, is within the College's control.

Although the program uses the most recent Autodesk 2014 software suite, Rock Valley College has not utilized the software to its fullest extent. Adjunct instructors teach both the introductory course and the advanced course. Each has their own style and approach. As

AutoCAD has advanced, a greater disconnect grows between the introductory class and advanced class. When a new edition is released, instruction is merely updated to adapt to the changes in software. For this reason, the courses were providing only minimal instruction consistent with industry standards, so the program offers little new to entice the industry to seek out the College's architectural Computer Aided Drafting (CAD) students. Programs like Sketch-up and NavisWorks have been discussed as possible curricular inclusions, but nothing had been done to research how to incorporate advanced programs and technologies into the curriculum.

1.2. Problem Statement and Research Motivation

1.2.1 Motivation of the Study

During the summer semester 2011, the author was introduced to theory and basic applications of Building Information Modeling (BIM) technology in CM&E 670: Information Technology for Construction Managers, a class conducted by Dr. Zhili (Jerry) Gao in the Construction Management and Engineering program at North Dakota State University. Realizing that Building Information Modeling (BIM) was the means by which future construction projects would be communicated, a brief literary review and research survey was completed by the author to explore the acceptance of the theories and application that make up BIM among the construction community in the Northern Illinois region. The research indicated that the concept of BIM was not on the regional architect, engineering, and contracting communities' radar at the time. Heating Ventilation and Air Conditioning (HVAC) contractors were the only industry professionals utilizing BIM technology at that time.

A five year comprehensive review of the Building Construction Management program at Rock Valley College was conducted in 2013. As a result of this review, weaknesses in the Computer Aided Architectural Drafting courses have been identified as requiring remediation.

The natural progression from these findings dictated a need to explore how the institution can offer a higher level of instruction to the student. Recognizing a need for BIM technology, the concern becomes whether or not BIM education could adequately be provided to two year community college students striving to meet two of the program's three principles: earning a degree with job placement, earning a certificate and achieving job advancement.

An Associate in Applied Science degree in Building Construction Management requires the successful completion of 65 credits in order to qualify for graduation. Of those 65 credits, 18 credits (six courses) are required general education courses. Of the remaining credits, 15 core curriculum courses are offered to students so they can develop a foundation to be competitive in an entry level position with a construction industry partner.

Not all students are pursuing an A.A.S. degree. Some intend to hone their existing skills while others hope to update their credentials by successfully completing requirements for a certificate. Certificates at Rock Valley College range between 15 and 18 credits and concentrate on a specific topic such as sustainable construction or materials and methods of construction.

In order to provide instruction for new technologies or develop evolving skill sets in students when new technologies emerge, courses must be evaluated for relevance to current or developing industry needs. Determining the most appropriate mix of classes and topics is the challenge; and without qualified individuals to provide instruction, an identified area of keeping current with emerging technologies goes un-served.

1.2.2 Problem Statement

With BIM becoming more mainstream in the construction industry today, Rock Valley College needs to determine the feasibility of offering meaningful curriculum in the area of BIM theory and methods; such curriculum may need to replace an existing course, or modify a current

course with a BIM component or simply adding a new course devoted to BIM theory and method. When adding, replacing, or altering an existing course, the college must take into consideration the constituency to be served and how to serve them. These are the factors that this research intends to address.

1.3. Significance of the Study

1.3.1 Prepare the Construction Industry Workforce with Marketable Skill

When BIM education is deemed viable in the CTE curriculum, the community college can be instrumental in offering a skill that is seemingly missing in the Northern Illinois and Southern Wisconsin region. The recipient of this education also benefits as this additional skill will make new graduates more marketable in construction and construction related industries.

The brief research completed in summer of 2011 determined that most of the industry did not anticipate needing BIM technology skills for five or more years. Some felt that because of their concentration in the market, these technology skills may never be applicable for the work they do. Less than a year later, agencies such as the Illinois Department of Transportation (IDOT) announced the intention to include BIM in upcoming projects (PTAC, 2012).

1.3.2 Bid Requirement for Awarding Future Projects

During an Illinois Procurement Technical Assistance Center (PTAC) conference titled *A Business Exchange for Construction Industry Professionals* held in October of 2012 at Rock Valley College in Rockford, Illinois; the State of Illinois expressed its intention to require BIM documents for successful acquisition of future state projects. At the same conference a representative from the Government Services Administration (GSA) informed the audience that GSA already required BIM on certain government contracts, though they were not specific regarding the type of jobs to which this requirement applies.

1.3.3 Improve the Bottom Line

BIM education can significantly change how projects are communicated in our region. In Brad Hardin's book *BIM and Construction Management: Proven Tools, Methods, and Workflow* (2009), the author exams the benefits of BIM technology. BIM provides the contractor, subcontractor, designer, vendor, and ultimately the owner with benefits such as reduced construction time, fewer change orders, and more accurate cost estimates. These benefits ensure a competitive advantage.

1.4. Objectives

In the process of addressing BIM education in the community college, a set of underlining questions, sub-problems (Leedy/Ormrod, 2013) and objectives (Stock, 1985) need to be investigated.

The basic objective of this research is to determine the feasibility of sustaining a curriculum that provides an adequate level of BIM education at a community college. Additionally, developing the BIM curriculum will rectify the shortcomings identified in the current Building Construction Management program review.

Below are the goals that will be investigated in this proposed research project:

- To establish any prerequisites that may be needed for a candidate to achieve success in meeting the objectives of the BIM course.
- To determine if a one-semester course can adequately address the theory of BIM and basic application of BIM tools to the community college student.
- To investigate which facet of the construction industry can best utilize the skills a student develops from the BIM curriculum at a community college.

1.5. Delimitations

This study centers on BIM education in North Central Illinois plus parts of South Central Wisconsin, specifically Community College District 511 (Figure 1), the district served by Rock Valley College and adjoining regions. Because of this concentration, the research will exclude a number of topics that may steer the research away from its intended purpose.

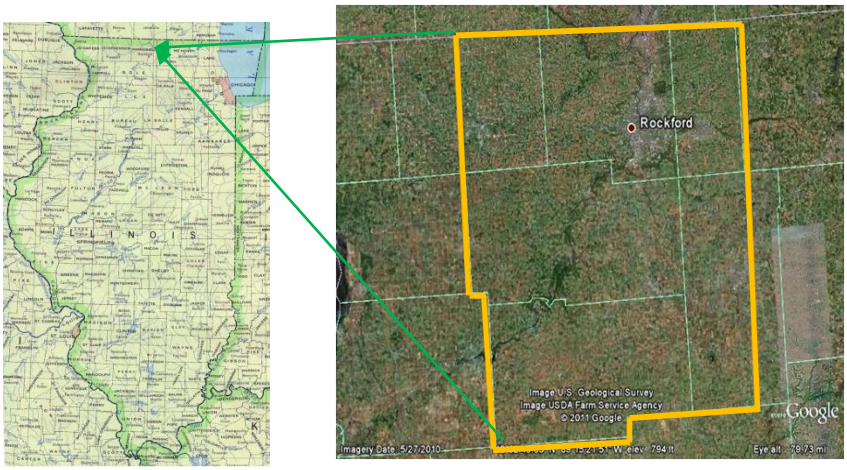

Figure 1: Rock Valley College, District 511

Again in establishing a successful CTE program at a community college, three principle outcomes for survival of a CTE program are necessary. This research will concentrate on the first: earning an Associate Degree in Applied Science, and the second, completing a certificate. Addressing the effects of BIM education for the transfer student (the third) requires a completely different set of parameters which is outside the scope of this project.

Residential construction operates on a different set of parameters than commercial construction. There is no similarity in the way project specification and drawings communicate the intent and details of the project. The primary area of focus for the Building Construction Management program at Rock Valley College has been commercial construction. In keeping with the mission of the department, this research project will not explore the opportunities BIM provides residential construction.

Peer groups beyond the state of Illinois and outside the specified South Central Wisconsin region will not be consulted for contributions to this research. Excluding South Central Wisconsin would not provide an accurate representation of the constituents served by the college. See Figure 2.

Figure 2: Illinois Community College and Wisconsin Technical College Districts

Source: iccb.org and wtcsystem.edu

1.6. Organization of the Paper

The organization of this paper is briefly described as follows.

- Chapter 1. Introduction: This chapter explains the catalysts that prompted the motivation for conducting a review of the existing CAD program, the research into BIM education, and the skill set it can provide students in the construction industry in the Northern Illinois/Southern Wisconsin region. The chapter also identifies objectives of the research that has been conducted to determine what success BIM education can have at the community college level.
- Chapter 2. Methodology: This chapter provides an explanation of the process used in review of a pilot program conducted at Rock Valley Community College and explains

how data was gathered and analyzed to develop recommendations for process implementation.

- Chapter 3. Literature Review: This chapter presents a brief history of BIM along with a review of previously conducted research and conference proceedings in the field of BIM education.
- Chapter 4. Data Analysis: This chapter assesses the data collected by material from the literature review, the findings based on the experience with the pilot program, and the results of the on-line survey.
- Chapter 5. Proposed Implementation: This chapter incorporates the finding of the literature review and the analysis of the on-line surveys to provide a strategy for creating a BIM curriculum for the community college student.
- Chapter 6. Future Considerations: This Chapter addresses expanded opportunities for a BIM Theory and Methods curriculum based on a successful initial implementation.
- Chapter 7. Conclusion: This chapter provides a summary of researchers' findings, strategies, and recommendations on the feasibility of effective instruction of the theories and methods of BIM education at the community college.

2. METHODOLOGY

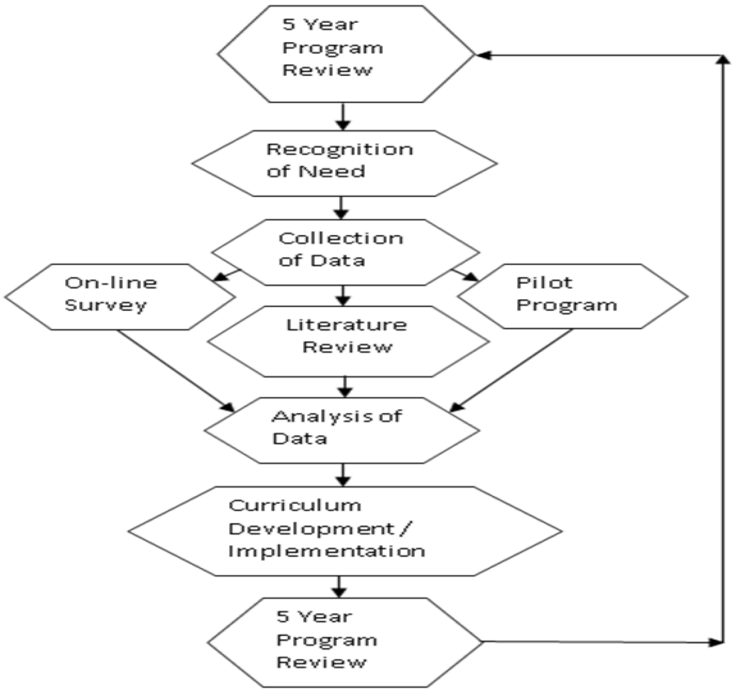

Figure 3: Research Methodology Flow Chart

The primary function of the research methodologies selected was to dictate and control the data obtained, and to analyze and extract meaning from the data collected (Leedy/Ormrod, 2013). Proper research methodology allows for more objective, less biased evaluation to take place. The lack of research found on BIM education at the community college level drives a triangulation of research methods. Without access to prior research, a single method or approach to conduct this research was inadequate. Multiple data sources needed to be compared in order to establish a common theme and support for the findings (Fellow/Liu, 2008). A variety of influences were considered in creating a successful plan for implementation. The main purpose of this research is to determine if a BIM curriculum is feasible to implement at the community college, and whether the local construction industry would support a BIM program by employing

those who earned a certificate or degree from a two-year institution. Figure 3 shows the flow chart for the methodology utilized for development of this study.

The motivation for this study stemmed from findings of a five year Program Review of the Building Construction Management Program at Rock Valley College. The deficiencies in the AutoCAD program were the catalyst for initiating research in BIM theory and method education.

This study looks at regional practices currently being used to communicate project requirements, i.e., working drawing created via AutoCAD versus the trends for other tools used on national or international scales. This study also looks at how one of those tools, BIM theory and methods, may be communicated through instruction at the community college level to expand the knowledge and use of this evolving technology in the construction industry in a particular geographic region, particularly northern central Illinois and southern central Wisconsin. This study was conducted through exploratory research because the historical data on BIM curriculum and education at a community college is lacking. To accumulate the data needed to gain understanding and knowledge of BIM education, and comprehend methods of instruction for developing meaningful student learning outcomes, the author reviewed scholarly articles and journals, surveyed two and four year Illinois and select Wisconsin educational institutions, attended a professional BIM education symposium, and initiated a pilot course at Rock Valley College in Rockford, Illinois.

The primary focus of this research was to understand current practices and expectations of the construction industry in the northern central Illinois and southern central Wisconsin region and their differences from national and international trends. Other points of inquiry investigated were other post-secondary institutions and program curriculum delivery to their students; and which institutions in the area of study have initiated such curriculums. Lastly, a pilot course was

implemented to understand best practices for develop acceptable student learning outcomes for first and second year college students.

Based on data findings from the three areas of inquiry, conclusions are formulated on the feasibility of BIM education in a community college setting, recommendations on a course of action submitted to academic council and ICCB for approval, and implementation of revised course of study in BIM theory and methods.

2.1. Literature Review

The Literature Review consisted of three primary sources: scholarly journals, articles, and publications about BIM integration into college and university curriculum and the challenges faced in doing so; BIM education symposium findings that examined BIM education by non-traditional methods of curriculum implementation; and review of course offerings from two and four year Illinois and select Wisconsin post-secondary education institutions. All of these provided insight into various degrees and courses featuring BIM curriculum.

The articles and journals reviewed were accessed through North Dakota State University (NDSU) on-line libraries, through subscriptions, or on-line resources. Authenticity of source, author, and content was closely scrutinized for academic content and validity. As part of the symposium proceedings, research papers were presented to the National Institute of Building Science (NIBS) for inclusion at the buildingSMART alliance: "BIM Academic Symposium" as part of NIBS *Building Innovation Conference & Expo 2014*. The author of this study attended this symposium and references are primary accounts of information presented. Course offerings from Illinois and Wisconsin post-secondary institution originated through review of the respective institution's websites. A complete Literature Review is outlined in Chapter 3.

2.2. On-line Industry Survey

In order to understand the regional construction industries understanding of BIM, an on-line survey was utilized for the data collection tool. The survey anonymously polled industry professionals from six different areas of the construction industry: general contractors; architects and engineers; Mechanical/Electrical/Plumbing (MEP) contractors; specialty contractors, (i.e., concrete contractors and masonry contractors); municipalities; and material suppliers. The main purpose of this survey was to deduce whether or not the regional construction industry was receptive to and would utilize the talents of students formally educated in BIM theory and methods. The survey was offered to industry professionals in the region outline previously in Figure 2.

The survey contained 22 questions. Some were open-ended (where those taking the survey were able to input a response or provide a comment) and some close-ended (where answers were chosen from a establish set of responses). This approach allowed for diverse responses and prevented respondents from being limited in their answers. At the end respondents were asked to add any additional comments they felt important to the survey, but which were not addressed by its options. The questioning followed four main premises: understanding of programming at Rock Valley College, company business model and BIM capabilities, desired competence level for BIM, and source and methods of implementing BIM training/education. Premise 1 sought the respondents' knowledge of the degree and course offering at the college, specifically the Building Construction Management programs. Premise 2 inquired about the respondents' business model, (i.e., architect or general contractor, etc.) and current technologies used to communicate project design specifically along the lines of BIM technology. Premise 3 sought feedback on the recommended mode of educating/training individuals in BIM theory and

methods. Premise 4 included questions about demand for BIM technology throughout the region. This complete questionnaire is found in Appendix A.

2.3. Pilot Program

2.3.1 Course Development

To best understand what type of competencies, with regard to knowledge of BIM theories and methods new students entering AutoCAD classes at Rock Valley College possess, a survey was sent to 29 high schools in the region. This survey had 16 close-ended questions with allowed for comments after selecting the desired answer. The line of questioning followed a similar path to the industry survey.

- Part I: Familiarity with Rock Valley College BCM programs,
- Part II: Level of students' idea of high school instruction with computer aided drafting software, along with the type of software used,
- Part III: Best practice for providing BIM education/training.

The complete survey is found in Appendix B. Not all students in the BCM programs enter directly from high school. Through both the industry survey and the high school survey a general synopsis of incoming students' knowledge and capabilities can be ascertained.

Prior to the start of the pilot program the Student Learning Outcomes (SLO) established by Rock Valley College were reviewed to ensure the course followed their directives. Using those outcomes, a course rubric was created in which to guide course instruction and evaluate student performance. Four course learning outcomes were defined for the rubric (Appendix C):

- Analytic Reasoning: Program will form logical inferences, judgments, or conclusions from facts or premises related to topics encountered in the classroom or daily life.

- Global Awareness & Responsibility: Program will develop the knowledge and skills required to responsibly interact with social and natural communities, both locally and globally.
- Communication: Program will exchange ideas effectively in a variety of settings.
- Personal Responsibility: Program will accept responsibility for students' personal and professional wellness and development, positioning the students for life-long learning.

These outcomes are modeled after the student learning outcomes established by Rock Valley College (Rock Valley College, 2013).

The intent of the pilot program was to ascertain the level of competency necessary to master successfully the objectives of both learning the theory of BIM and implementing its practical use. The curriculum was delivered as a hybrid course with students and faculty meeting for three hours during the week in a traditional classroom setting. The students were also expected to dedicate time each week outside of the classroom to meet course requirements. That amount of time was predicated on the individuals existing knowledge of CAD. Three credits were offered for this course. Additional time to study the course material and complete assignments was necessary for students to succeed as in any other credit course. The instructor asked students to track their additional time dedicated to the course.

The student success and competencies with regard to BIM, its theory and concepts were evaluated through two quizzes and their success and competencies with regard to communicating BIM concepts through CAD (Revit) were evaluated by completion of a semester project. The project provided a more comprehensive evaluation of student learned competencies' on material presented throughout the semester.

2.3.2 Course Implementation

Because this research is designed to define baseline competencies, the instructor, along with the author, developed a rubric that assisted in evaluating student learning outcomes success (Appendix D) based on the final project. The rubric provided guidelines to evaluate success by assessing the level of knowledge exhibited at the start of the course, and comparing it to mastery of the concepts at the end of the course. Determining whether a community college can provide a meaningful level of competency with a theoretical knowledge base, are the desired outcomes at the conclusion of this study.

The instructor designed the course curriculum under the parameters that it was to be an eight week lecture and lab course with the students required to spend time outside of class working on course concepts. The course follows the structure established in the program rubric developed by the Building Construction Management program's academic chairperson with approval from the Dean of Rock Valley College's Engineering and Technology Division. Although content for the curriculum was defined, each instructor has academic freedom in the delivery of that content as long as it complies with the rubric. The course syllabus with course outline are attached for further review (Appendix E).This hybrid course was designed for lecture to occupy a three and one-half hour window seven of the eight weeks. Each student was then required to perform laboratory work outside of class with the instructor being available to answer questions via telephone, email, or the college's learning management system during established office hours and/or at his convenience outside of stipulated office times. The course design and curriculum was submitted to the college as a special topics course: BCM 250: BIM theory and Methods.

Prior to the start of the course, the instructor presented the students with a questionnaire to evaluate their experience and understanding of BIM theory and practice (Appendix F). The first part of the survey was based on students' knowledge of the construction industry and the design software it uses. Once the eight week pilot program was complete, and the program's student learning outcomes were evaluated, the instructor had the student fill out the questionnaire a second time so they could self-evaluate growth and competence of the material presented. The instructor's review and student evaluations conducted through an on-line survey were presented to the Advisory Committee for validation of the college's ability to provide comprehensive BIM education. The author's questionnaire (Appendix G) was approved by the Institutional Review Board (IRB; IRB Appendix H.) at North Dakota State University because of its use of human subjects. SurveyMonkey was the web-based survey solution provider. 22 Questions were solicited through the author's survey to students who enrolled in the course. Students were instructed when receiving the survey that they were in no way obligated to respond to any or all of the survey. Several lines of questioning were introduced asking students to provide information about the following: A) Levels of prior knowledge and experience with BIM technology and/or other project communication software. B) Effectiveness of the structure of the course. C) Overall satisfaction with the course. D) Future recommendations for the course. Overall, student's impressions of the pilot program were favorable; and feedback will assist in augmenting the curriculum for presentation to the College's curriculum committee for review and implementation. The results are expressed later in this paper.

2.4. Data Analysis

The qualitative data collected through the surveys, pilot study, and literary review were analyzed for common themes to determine the direction and focus for implementing a new BIM

theory and method course curriculum. The data articulates the answers to the standard questions of who, what, when, where, why, and how. Who will primarily benefit from BIM course work? What will be the BIM technology utilized during the course? Where is the most conducive location to offer course work? Why should the community college undertake a change in architectural drafting curriculum? How will this new BIM theory and method curriculum be delivered? Collectively, between the different entities researched, definite trends emerged to provide direction on how to solve the issues address above.

2.5. Analysis Procedure

This case study conducted qualitative analysis of the feasibility of Building Information Modeling at the community college level. The study was not intended to solve a hypothesis; its purpose was to extrapolate information based on the results from surveys, a pilot program, and a comprehensive literature review. Basic steps were followed to analyze survey responses, compare them to literature review findings, and make a determination as to how they apply. The steps taken are listed below:

- Conduct a comparison between current industry practices and determine which practices are national and what industry practices are regionally.
- Conduct a comparison to cohort institutions implemented as offering for curricular and compare it to desirable regional industry standards.
- Evaluate curriculum currently offered at the secondary school level and assess whether it articulates to post-secondary institutions as well as provide the necessary skill sets established by the industry within the region.
- Draw conclusions based on the analysis on how the pilot program curriculum at Rock Valley College compared to regional practices, national practices, and regional

industry practices; while positioning itself as a viable means of providing progressive education and training for the construction industry in Northern Illinois and Southern Wisconsin region.

2.6. Implementation

Based on survey analysis, the results of the pilot program, and literature review, it is recommended that Rock Valley College implement curriculum development for a course whose primary focus is on BIM theories and methods. The qualitative method of reviewing data supports the finding for implementation.

3. LITERATURE REVIEW

3.1. History

The conceptual foundations of BIM are recognized as early as 1962 when Douglas Englebart presented his vision of architecture in his paper *Augmenting Human Intellect: A Conceptual Framework.* In his paper, Englebart supposes parametric manipulation, object-based design, and relational databases, concepts that would later be realized. In 1964 another pioneer, Christopher Alexander, influenced the early computer scientists with object-oriented programming. And, again, in 1969 Ian McHarg authored a landmark book *Design with Nature* that has arguably had a great influence on the development and application of the Geographic Information System.

The missing component of these early innovations was a graphic interface to interact with. Two early means of displaying and recording shape information were constructive solid geometry (CSG) and boundary representation (Bergin 2012). CSG uses primitive solid or void shapes that can be combined, subtracted, and/or intersected to form the appearance of complex shapes. In architecture, CSG can represent common procedures in design such as doors and windows. Many precursors to CAD and BIM technologies were entwined in the space race and Cold War during the 1960's and 1970's. De Monchaux's (2011) explores many of these human-computer interaction contraptions in his book *Spacesuit: Fashioning Apollo.*

Understanding the architecture of a building requires it to be broken down into its constituent components. This is done on a computer by creating component databases. In 1975, Charles Eastman was one of the first to successfully create a component database by developing the Building Description System (DBS). The DBS was the first software that allowed individual building components from a library to be inserted into a model. It was estimated that the system

could save the cost of design by 50%. Eastman described his work as a working prototype, a "single integrated database for visual and quantitative analyses." In 1986, Robert Aish was the first to coin the phrase Building Modeling in the way it is used today, and in 1992 the term Building Information Modeling was documented in a paper by Nederveen and Tolman. Ten years later Jerry Laiserin (2002) tried to further popularize the term. However, Laiserin doesn't take credit for creating the term nor for developing the process; in his introduction to the *BIM Handbook,* he dubs Chuck Eastman as the "father of BIM" (Eastman et al. 2007).

3.2. Articles

In understanding whether BIM can successfully be integrated into the community college curriculum, a literature review was conducted to explore processes and services from academic institutions, construction contractors, design firms and professional organizations. Defining the concept of what BIM is and the role BIM plays was a common focal point while conducting this research. The omphalos role of BIM in the construction industry may best be expressed by McGraw-Hills BIM SmartMarket Report: "Your career and the prosperity of your company depend on becoming familiar with the tools, processes and value propositions of BIM" (Young et al. 2009a). BIM is not just another tool used in the creation of working drawings. It is a comprehensive means for managing information and conducting analysis on a project, a new way of thinking distinctive from CAD (Sacks, Pikas 2013).

Construction is going through a major transformation both in technology and in institutional structure (Ahn et al. 2013). What's pushing the industry to a BIM culture is the multiple functions BIM can serve in construction projects. Harmann and Fisher (2008) reported at an *eConstruction Roundtable* in 2007 that utilizing BIM on projects regularly realizes 20 to 30 percent greater productivity with an exponential reduction in Request for Information (RFI), and

substantially greater involvement and support from all critical stakeholders. Young et al. (2009b) notes that half of the contractors who reported to their study were currently using BIM and by 2012, predicted that the number of contractors who incorporate BIM, in their business model would double.

With hundreds of accredited civil, architectural, construction engineering, and management degree programs in the United States, a limited number of them offer curriculum with content that is BIM concentrated. The reality is that most universities struggle because there is no common understanding of skills necessary for the industry; nor is there agreement on common content, principles, or methods of education needed in the fields that include BIM (Sacks, Pikas 2013). At the university level according to Tatum (2011), it is imperative that programs in construction or civil engineering propagate core knowledge of four elements: scientific fundamentals, construction materials, construction applied resources, and field construction operations. In their document *The Civil Engineering Body of Knowledge for the 21st Century* (CEBOK) (ASCE 2008), the American Society of Civil Engineers (ASCE) requires a student in civil engineering to have a solid understanding in four core outcomes: natural science, mathematics, humanities, and social sciences. A number of studies have referenced the integration of BIM into curricula using different approaches and methodologies (Sacks, Pikas 2013), yet there is no widely accepted approach for teaching BIM in Architecture/Engineering/Construction (AEC) programs (Woo 2006). For the majority of institutions, limited courses exit where BIM is covered. BIM is usually introduced early in the curriculum, with content only introducing the topic (Sabongi 2009). Institutional course work is predominately based on teaching BIM as a productivity-enhancing tool for working drawings. Ahn, Cho, and Lee (2013) developed an undergraduate BIM course suited for construction and

engineering programs by using Tyler's (1949) systematic approach to course-development which includes three phases: preparation, development, and improvement. They felt that this new BIM course would benefit construction program students with the skills necessary to apply BIM effectively as well as provide comprehensive knowledge about the importance of application in construction projects. Educators themselves find it difficult to keep up with the evolution of BIM. Rapid technology changes, the ability to educate instructors, and established curriculums all present challenges to BIM education (Raphael 2009; Gordon et al. 2009; Denzer and Hedges 2008; Clevenger et al. 2010; Sabongi 2009).

An alternative approach integrates BIM across the course offerings. With this approach, BIM topics can be divided up and addressed in the course disciple to kindle learning and satisfy student learning outcomes (Sacks, Pikas 2013). Sacks and Pikas (2013) indicate that, in general, if BIM education is to be successful, its topical integration should be spread over the years of an AEC program. During the freshman and sophomore years, the focus should be on the fundamentals: basic modeling skills, parametric modeling with standard elements and constraints, and solid modeling (Sacks, Pikas 2013). Additional industry organizations, such as the American Institute of Architects (AIA) and Associated General Contractors (AGC), have also recognized the growing popularity of BIM and have developed guides and contract forms that include ConsensusDOCS 301 BIM Addendum and the GSA BIM guide (Young et al. 2009b) to address BIM and its use on a project.

Students comprehend the intricacies of the built environment through visual and/or hands on applications (Boon, Prigg 2011). BIM can provide the platform to accomplish this from both a method and material aspect. The incorporation of BIM education will expand career opportunities for the engineering and/or construction student (Wong et al. 2011).

Integrating BIM into an AEC program does not come without obstacles. Three challenges were identified by Kymmell (2008): the large learning curve in learning and using BIM software, misunderstanding of the BIM processes, and the conditions of the academic environment. Taylor, Liu, and Heim (2008) commented that to be proficient at modeling, an individual must possess knowledge of the built environment; most students lack that knowledge because of inadequate work experience. Young et al. (2008) is in agreement that the availability of training is the greatest obstacle to widespread adoption of BIM in the construction industry.

3.3. Symposium Proceedings

On January 10, 2014 the National Institute of Building Science Conference & Expo's Building Innovation 2014 was held in Washington, DC. A one-day Academic Workshop whose objective was to present the contributions and approaches used by academic programs to promote technology-based collaboration through Building Information Modeling (BIM) educational activities at various levels of post-secondary curriculum in order to attain the desired educational outcomes through credentialing, accreditation, or certification.

The day offered 12 presentations by various industry and academic professionals. Although none of the presentations addressed BIM at the community college level, six presentations did offer insight into how BIM was being integrated at traditional four-year institutions. Three of the presentations centered on ancillary issues associated with the use of BIM. An example of this was a presentation on copyright law. Two presentations referenced industry perspective. One discussed integration at the graduate school level. This section will review those symposium proceedings and look at how information presented can be utilized to enhance BIM curriculum for the community college program.

The six presentations that addressed BIM integration at four-year institutions were each presented from different perspectives, but with a shared goal of introducing Building Information Modeling into the curriculum. Caroline Clevenger and Rodolfo Valdes-Vasquez, both Assistant Professors at Colorado State University (CSU), introduced BIM into the curriculum at CSU in Fort Collins, Colorado in the Center for Virtual Design and Construction (VDC) (Clevenger, Valdes-Vasquez; 2014). Professor Haiyan Xie, University of Arkansas at Little Rock and Associate Professor Carrie Boden-McGill, Associate Professor, Texas State University research educating students on BIM technology through the use of a Structured Discovery Learning Strategy (SDLS), more often referred as Structured Discovery Learning (SDL) (Xie, Boden-McGill; 2014). At Western Kentucky University, Assistant Professor Shahnaz Aly integrated BIM concepts in undergraduate architectural science Capstone projects. The University of Wisconsin-Stout introduced teaching BIM using Universal Design for Learning curriculum strategies within interdisciplinary, undergraduate courses (Rodriquez, 2014). Two additional institutions, Georgia Southern University (Maghiar, 2014) studied BIM integration in Planning and Scheduling curriculum while the University of Oklahoma (McCuen, 2014), examined "The Challenges of Advancing BIM in the Curriculum while Addressing Current Accreditation Standards for Construction."

3.3.1. Course Deliveries

3.3.1.1 Structured Discovery Learning Strategy

Xie and Boden-McGill's (2014) study of Structured Discovery Learning (SDL) allowed students to learn and think independently, achieve self-discovered knowledge, and master principles of BIM technology. This direction is designed to instill independent learning, group collaboration, and creativity. SDL is a method for acquiring cognitive problem-solving and

perceptual skills by means of actively participation in the learning process (Nyman, 2001; Ryles, 2008). The instructor's role is to direct the students on how to verify conditions and /or assumptions of a project and solve those issues either in a class or on their own. The authors found that the discovery process gave the students a sense of achievement. The following model (Figure 4) shows the process taken in conducting the course.

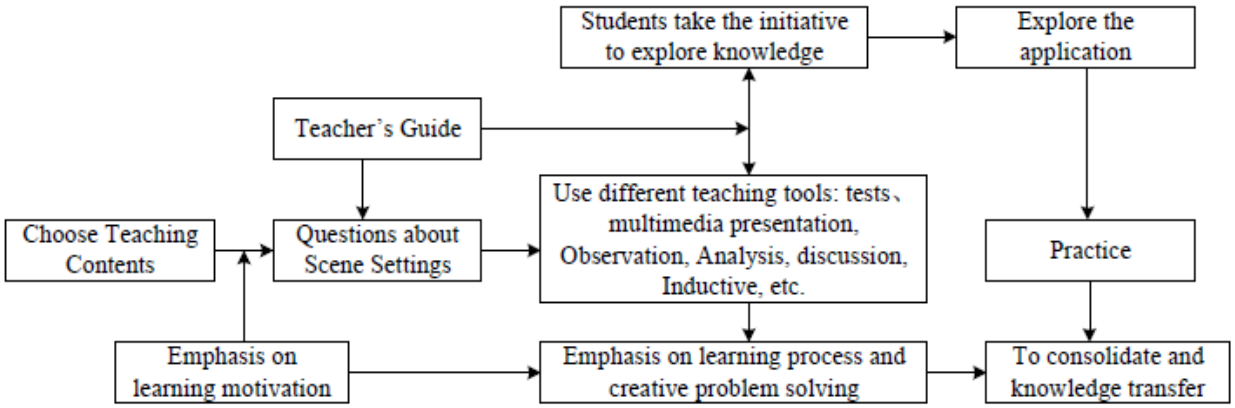

Figure 4: Structure of the SDLS teaching model; (Xie/Boden-McGill, 2014)

The first step is choosing teaching content. The second is inquiry learning. The third uses SDL in BIM project design and the fourth culminates in building the conceptual design frame work. Open-ended projects and/or homework assignments take place in steps three and four. SDL allows students to have improved learning and comprehension by guiding them through the discovery process (Xie, Boden-McGill; 2014).

Advantages in BIM education through an SDL method include: 1) allowing the student to discover answers to their questions on their own; 2) the improved flexibility of the course as the students collectively create the processes of knowledge discovery (Xie, Boden-McGill; 2014). Yet, with advantages come disadvantages. Without providing a steadfast correct answer, a student's ability to distinguish correct answers from incorrect answers may diminish the learning process. Too much collaboration and research during a class session may also reduce class

efficiency by not allowing students time for independent study (Hannafin at el. 1999). Others also have questioned the effectiveness or efficiency of the SDL model. In a 2012 case study (Clark et al.), it was determined that when presenting new skills or information, step-by-step instruction with explanation worked best. Alfieri (2011) commented that assisted discovery learning was much more effective and beneficial to learners than unassisted learning.

3.3.1.2 Universal Design for Learning

Glendali Rodriquez, Associate Professor, University of Wisconsin Stout introduced BIM using Universal Design for Learning curriculum strategies within interdisciplinary, undergraduate sophomore-level Architectural Technology courses. These are standard three credit course that meet twice a week in a lecture/lab setting. The students and faculty use the "eStout Program," a digital learning environment that ensures having a standard set of hardware and software tools that meet wireless computing needs (UW Stout Learning and Information Technology, 2013). The course is administered with the objective that it will prepare students with management skills that will be required to succeed in the AEC industry; an emphasis is placed on communication and documentation. The UDL framework is defined by the Center for Applied Special Technology [CAST] and provides three principles for creating curriculum; the what (means of representation), how (means of expression), and why (means of engagement) of learning (CAST, 2012). UDL's framework allows for flexibility in how information is presented and in how a student demonstrates understanding of that information. It also breaks down barriers in instruction by providing accommodation, support, and challenges while maintaining notable achievement expectations for all students (Higher Education Opportunity Act, 2008).

UW-Stout addresses each of the UDL principles in the course. Principle I is accomplished by including all syllabi, lecture materials, online links, and text references on the

school's content management system (CMS). Assignments, deadlines, in-class demonstrations, and grading rubrics are not only covered in class, they are also posted along with narrated "on-screen captured" tutorials to assist with the completion of the BIM assignments. Principle II allows for choice of research topic along with the format in which it will be submitted. Principle III allows for varied methodologies presenting content and format, all of which assume that individuals learn differently (Rodriquez, 2014).

Assessment is done both quantitatively and qualitatively on individual and team assignments, total course evaluation, and informal class participation; continuous improvement is the goal. The course is a prerequisite to other courses involving scheduling, estimating, and MEP systems. An introductory architectural drafting course is required before taking the BIM course.

Software programs utilized include Autodesk AutoCAD and REVIT Architecture, along with Microsoft Office. The author outlines additional worthy resources that helped in the set-up and delivery of the course. One was Jing, a free screen capture and short video narration tool. It can record mouse movements to narrated tutorials (Techsmith, 2013). Others include learning services such as Lynda.com, Autodesk tutorials, and user-based blogs and forums.

3.3.1.3 Capstone Projects

The Architectural Science Program in the Department of Architectural and Manufacturing Sciences at Western Kentucky University has a two semester capstone course in its curriculum. The capstone course sequence is an applied research experience through which the students are expected to demonstrate mastery and competence in architectural science (WKU Undergraduate Catalog 2012-2013). The capstone course is an active learning experience with substantial time and effort require by the students from proposal to implementation. Concepts and knowledge acquired through program course experiences are expected to be applied on

projects to demonstrate readiness for graduation and productivity in their career. Capstone courses are designed to show "how all the pieces of the puzzle fit together" (Jones et al. 2009).

For this capstone experience, the first course was a Comprehensive Design class during fall semester senior year. Students were encouraged to use BIM tools for their Capstone project, predominately Revit. Requirements of the course were to identify the project and client, and establish a proposal for the project. The second course, Senior Project, offered spring semester of the senior year, continues the schematic design, through design development, and culminates in a presentation with working drawings. The capstone finishes with project presentation to client, faculty, and industry. To further enhance the capstone experience, Shahnaz Aly (2014), Assistant Professor, recommends the following should happen: (i) make the BIM course a pre-requisite to the capstone experience to reduce the learning curve of BIM during the experience, and (ii) provide more complex BIM topics in the BIM course to better prepare students for their capstone projects.

3.3.1.4 Virtual Design and Construction (VDC)

Caroline M. Clevenger, Assistant Professor, and Rodolfo Valdes-Vasquez, Assistant Professor, along with Graduate Research Assistances (2014), transformed an existing classroom into the Mortenson's Center of Virtual Design and Construction for the Department of Construction Management at Colorado State University (CSU). The purpose of this new center is to provide an interactive and collaborative learning environment where students can focus on, learn the capabilities of, and gain knowledge and experience with modeling programs used during the Centers design and construction. The design and construction of the Center itself was an exceptional opportunity to showcase a model of a BIM-enabled construction process using

two cross-curricula teaching modules developed for future use: laser-scanning and energy modeling. Being a dynamic space, the center is designed to evolve with new technologies.

3.3.1.5 BIM Integration in Planning and Scheduling

Typically, educators incorporate BIM tools with the building design and only mention incorporation with project planning and schedule as a consideration for later investigation. Dr. Marcel Maghiar (2014) with the Project Planning and Scheduling course at Georgia Southern University, utilizes half a semester to concentrate on the foundational elements of scheduling. Prior to mid-term, P6 (Primavera) computerized scheduling software is introduced to develop, monitor, and update project schedules. Instruction is accomplished through lectures and laboratory sessions and reinforced by a diverse group of guest lecturers. During lab time, students follow structured tutorials and videos to enhance proficiencies demonstrated through real-world situations. The tutorials present step-by-step navigation guides that help navigate through the software; this allows for learning to be easily accessible and self-paced. BIM was incorporated into scheduling curriculum through the use of SYNCHRO software which is introduced toward the end of the semester. Students experience how a schedule is applied to a model through use of SYNCHRO. With additional tutorials, students use their lab time to master the process. Once comfortable with the skill set, they are encouraged to attempt more challenging aspects of SYNCHRO modeling.

At Georgia Southern University BIM theories and applications are spread throughout all four years of the Construction Management program. Courses where BIM concepts are introduced include year one: Computer Concepts and Computer Applications; year two: BIM for Construction Managers; and years three and four: Project Planning & Scheduling.

Unfortunately, the standard 15 week semester limits the ability to cover fully the theoretical, practical, applied topics, and visualization of the process.

3.3.2 Addressing Current Accreditation Standards

Because of the contributions BIM can provide to industry by means of knowledge and education, construction accreditation organizations such as the American Council for Construction Education [ACCE] and the Accreditation Board for Engineering and Technology [ABET] find it very valuable and necessary for construction programs to seek industry involvement (McCuen, 2014). ACCE includes a section in its standards and criteria Document 103 to assess this relationship (ACCE, 2013).

McCuen's (2014) research revealed two significant hurdles for educators. The first is how to integrate BIM into a curriculum and still fully meet the standards set by the accrediting organizations. The second problem asks the best way to integrate BIM into a construction program's curriculum. Currently, based on research by Becerik-Gerber et al. (2011), BIM is integrated into a construction programs curriculum in three ways: 1) as part of an existing technology course, 2) as part of existing construction courses, or 3) as an independent course. The majority of BIM courses being offered are electives.

If accredited or seeking accreditation by one of the leading accreditation organizations, the institution must be cognizant not to stray too far away from the standards and/or criteria in which the institution will be assessed. ACCE Document 103: Standards and Criteria (ACCE, 2013) specifies nine areas of assessment. The ACCE identifies five curriculum categories. Of those: Construction Science, Construction, and "Other" address actual construction program course requirements. At University of Oklahoma, Associate Professor Tamera McCuen feels Construction Science best serves to teach fundamental subject matter concepts, principles and

procedures in order to effectively implement BIM strategies. The “Construction” curriculum category provides instructors the best opportunity to integrate construction specific BIM tools into classroom or lab setting. ACCE proposed a new standard for accreditation in 2012. The proposed standards will base assessment on learning outcome criteria which will use Bloom’s taxonomy for learning as its framework.

3.3.3 Restricting Factors

Continual changes in the construction industry become a challenge for construction programs and their curriculum. General knowledge of software and how to integrate it is important; however, versions change which requires constant updating. In BIM development, it is important that BIM is used especially in a manner that develops interaction between project stakeholders. The adoption of integration software should provide the features and capabilities for project planning and scheduling. It is important to have management skills that will facilitate the BIM process. It is also advantageous to understand the trades or systems that make contributions to the BIM processes.

Constructability and job site planning activities also ranked high as benefiting from the use of BIM tools. The construction industry has been identified as lacking trained BIM personnel to fill these positions. This poses a problem for organizations that plan to adopt or are in the process of implementing BIM (Becerik-Gerber, Gerber & Ku, 2011). The lack of qualified instructors at the post-secondary level also slows the development of BIM curriculum being developed and implemented.

McCuen (2014) suggests that constricting factors exist for construction programs to meet the needs of industry; these factors include available resources and the current accreditation standards. McCuen concedes that there is not an abundance of research that exists in this area;

however, it is noted that there is a disparity between integration rate of BIM in curricula and adoption in the industry.

McCuen found that construction programs with BIM courses teach students skills in how to use BIM software in class on projects, whereas students in the architecture and engineering program courses are more often required to learn those skills on their own. Other aspects of McCuen's research revealed that only 36% of undergraduate construction programs require BIM coursework and, in general, undergraduate programs offer just over three BIM courses in the overall curriculum. As for limitations, it was reported that 45% of the programs lack resources for teaching BIM and 27% find the lack of BIM accreditation a barrier for further integration of BIM into the curriculum.

3.4. Peer Review

3.4.1 Illinois Institutions: Community Colleges

The state of Illinois has 39 community colleges with 49 campuses within its system. This community college system is governed by the Illinois Community College Board (ICCB). To compare curriculums between Rock Valley College and its sister institutions, a survey was conducted by means of review of the colleges websites. A detail review of course catalogs show that computer generated drafting and/or design is spread over a variety of disciplines. These disciplines include: Construction, Architecture, Facility Management, and Drafting. Depending on the discipline, a student could become a completer by multiple methods. He/she can earn a certificate in a respective program, an Associate in Applied Science degree, and in some instances an Associate of Science degree. The list of colleges and represented programs are included in Appendix I of this paper.

Of the 49 campus in the Illinois community college system, 25 offer a degree program which has a component in architectural computer generated drafting and/or design (ACGDD). Of those 25, 24 offer certificates that include course work in ACGDD. Twenty-one institutions describe offering course work in 3D; 11 specifically reference Autodesk Revit, and seven make reference to teaching a BIM theory course. The comparison between Rock Valley College's BIM theory curriculum and other Illinois community college curriculum is outside the scope of this paper.

3.4.2 Illinois Institutions: Four Year Institutions

Research on ACGDD at four year institutions within the state of Illinois was conducted in similar fashion to research conducted about ACGDD at community colleges in the state. Because the state of Illinois university system does not fall under a single state system, and because a number of private institutions reside here, identifying the disciplines that support the ACGDD course of study posed some difficulty. The list of four year institutions in the state was narrowed down to nine by use of Career Index, an educational data base. The search included Architectural schools and Construction Management schools. Upon identification, each institution's website was inspected for their contribution to ACGDD and more exclusively BIM. Out of the nine universities (listed in Appendix J), seven specifically identify as having a BIM program. Three mention Autodesk Revit by title and all nine offer a Bachelor of Science degree in Construction Management or Architecture. One university referenced using AutoCAD 2000.

3.4.3 Wisconsin Institutions

Wisconsin's University System is much different than the Illinois system. All public two and four year institutions are part of the University of Wisconsin system of schools. The two year schools (community colleges/junior colleges) are considered trade or technical institutions.

Yet whether a two or four year institution, all participate in an articulated agreement (Appendix K). Wisconsin also has a variety of private higher education alternatives. These, too, are two and four year schools. The research for this paper concentrated on review of those schools, public or private, that offered courses of study in Building Information Modeling in either their construction or architecture programs. The search of institutions was limited to colleges and universities south of Interstate 94, east of Madison, Wisconsin and south of Highway 18, west of Madison, Wisconsin. The one exception to this was the University of Wisconsin Stout because of the Rock Valley Colleges' current relationship with the university.

Within the Wisconsin area, 10 colleges or universities offer degreed or certificate curriculums in the areas of architecture and/or construction management. Three of these schools are two-year state technical colleges, three are state four year universities, three private colleges or university, and one technical school. Of the 10 schools, seven specifically address Revit with five actually listing BIM as a function of their course of study. Three of the schools that do not reference BIM simply make comment to having 3D capabilities. Two referenced only having AutoCAD.

4. SURVEY DATA DISCUSSION AND ANALYSIS

4.1. Survey Data

The survey data referenced in this chapter originates from the on-line surveys (Appendix A, B, G) described in Chapter 2. Methodology. The Survey was sent via email to designated industry and education professional for their perspectives on BIM theory and Method education in the Northern Illinois and Southern Wisconsin region. The contents of the student survey received approval by the Institutional Review Board at North Dakota State University (Appendix H).

4.1.1 Industry Evaluation

The industry groups' representation includes companies from different facets of construction and connected industries and/or organizations. Those groups include general contractors, architect/engineers, and sub-contractors who are subdivided into MEP contractors and contractors who predominately concentrate on a single trade.

When asked, "What exactly is BIM?" half of the architect/engineer group identified BIM as 3D rendering program; the other half termed it a new Autodesk AutoCAD suite. The General Contractors all labeled BIM as 3D rendering programs. Sub-contractors, MEPs, and municipalities all dubbed it a 3D rendering program. In total, of those surveyed, 70% designated BIM as a 3D rendering program and 30% felt it to be another Autodesk AutoCAD suite. When ask to define BIM in greater detail, most of the respondents offered similar definitions. A general contractor explained it this way: "Clash detection, renderings, estimating for buildings, time-lining." An AE defined it being: "3D modeling to replicate the actual design in order to see potential conflicts or other design issues prior to construction." While these responses all include

elements of the BIM process, others of the group are yet to comprehend the BIM concept. With that question, the researcher also received comments as: “too complicated” and “no clue”.

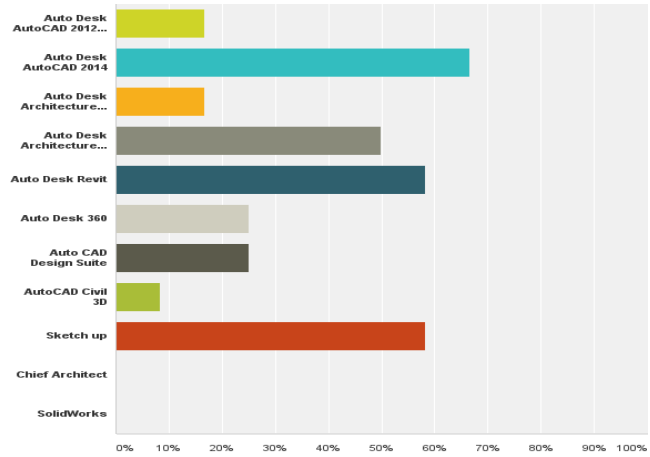

Figure 5: AE Firm CAD Capabilities

When the construction industry group was asked about what they are currently using for an integrated project delivery method, the Architect/Engineer (AE) delegation offered the greatest response with 12 of the 27 poled responding (44%). Of the respondents, 66% of the firms are working with AutoCAD 2014 and 50% of the firms also having Autodesk Architecture 2014. As for the 3D software, 58% of the group used Sketch-up or Revit equally. A small percentage of the firms used ancillary design software (see figure 5). Along with design software capabilities, 100% the AE group utilized Microsoft Project and 33% use Navisworks integration software as a complement to their program. Depending on the firm, other software considerations included Bluebeam, Photoshop, and InDesign. Of the firms responding, 33% currently support BIM capabilities in house. Another 50% of the AE firms are considering developing a BIM program for their organization. Surprisingly, 17 % indicated that they do not see implementing a BIM program. For those that do not foresee initiating a BIM program, their minds would be changed if it becomes required to solicit work through public entities such as local municipalities or federal agencies including Government Services Administration (GSA).

The most popular means of educating or training staff members in competencies in BIM, would be to send staff member to BIM training although hiring an individual with a bachelor's degree or BIM experience would also be a viable alternative. Only about one-third of those responding felt an Associate Degree would be substantial enough as a minimum requirement. One firm thought it beneficial for a candidate to have a graduate degree, while another firm would much rather "farm" the work out to a subcontractor. The results are expressed in Table 1.

Table 1: Minimum Qualifications for BIM Technician (more than one selection was permitted)

Answer Choices	**Responses**	
Send current personnel to training	58.33%	7
Bachelors degree	41.67%	5
Graduate degree	8.33%	1
Associate degree	33.33%	4
A degree isn't necessary; BIM experience is more important.	41.67%	5
We would sub-contract the process out to others.	8.33%	1
Total Respondents: 12		

Overwhelmingly 90% of the AE profession would consider Rock Valley College to conduct BIM training. Over 70% prefer it presented as standalone training or as part of adult or continuing education rather than being part of the degree program. Still, being presented through traditional education as part of a certificate program was determined acceptable and finished second as a preference with 55% approval. Note that those responding were able to select more than one option. None of the group supported presenting as an accelerated eight week course, and just 27% felt a degree path was the viable option.

The topic of BIM and BIM education is not considered a priority topic of the general contracting community in the Northern Illinois/South Central Wisconsin region. Of the 22 general contractors that were asked to comment, only four offered response. Three of the four have a version Autodesk AutoCAD 2012 or older. Along with AutoCAD they have Revit. Two

of the four firms use Sketch-up; one has AutoCAD and Revit 2014 along with other Autodesk products. Three of the four companies use Microsoft Project, while Bluebeam, Navisworks, Inventor, and Sage Suite has one company utilizing these different products. Three of the four companies chose not to respond to the questions asking about their best understanding of BIM. The fourth considered BIM a 3D rendering program. Three of the firms best describe themselves as general contractors while the fourth considers their business model as a design-build operation. Most of these companies solicit for contracts; three say 75% of their work comes from negotiated contracts, while the fourth contractor says all their work is negotiated.

When discussing BIM programs within the business, one company is considering it, one already has had the capabilities for the past four to seven years, and the final two have not considered it. In response to what would motivate the companies who are not supporting BIM to add BIM tools, both expressed it would have to be customer driven. Similar to the AE industry, the general contractors and design-builders think the best way for their organization to pursue a BIM program is through sending current personnel to BIM specific training or hiring someone with current BIM experience. One contracting firm indicated they would not bring the program on board; instead they would subcontract the process out. Ironically, all four would consider the community college as a reliable venue for providing the necessary training through a certificate program or standalone training. Two of the four companies have had inquiries from clients about BIM capabilities. As well, two of the four have had conversations about BIM with other construction professionals. One has said the question has not come up.

The author also reached out to other areas of the construction industry. Twelve MEP contractors were asked to comment, but only one did; 15 vendor/supplier requests were made with only one response; 11 trade specific contractors were solicited but with zero response.

Because of the low responses from these areas, their information would not have provided a true representation of the desires or capabilities of their industries, so that information is not included.

4.1.2 Public Entity Evaluations

As part of the research on determining the needs for BIM education in the region and how or whether the community college can or should provide it; the author polled the municipalities that represent the majority of the population for this region. Even though Illinois Community College district 511 does not cover South Central Wisconsin, it has proximity to and a history of drawing students from that area; we would be remiss not to include those Wisconsin public entities. The author contacted 10 public entities, which included city and county agencies involved with building and community development. As with the responses from MEP, sub-contractors, and vendor/suppliers, responses to inquiries regarding how or if they use BIM were slight. Four of the 10 municipalities responded.

Of the responses, one utilizes AutoCAD 2014, and one AutoCAD Civil 3D. Those that responded recognized BIM as a 3D rendering program. One municipality responded that their projects are 50/50 between negotiated and sent out for bid, while one municipality reported that all their work is on a negotiated basis. None of the municipalities have considered incorporating BIM into their business model. To do so, it would have to be mandated through a government agency such as GSA. If that were the case they would send current personnel for training. The community college would be considered for use as that training partner. Those responding were split on whether the training should happen as a certificate program or through adult and continuing education. To date, none of the entities have had requests for BIM capabilities.

4.1.3 Secondary School Evaluation

High Schools are the predominate source of new students for a community college. To best serve students' needs, it is important to understand their abilities. 27 area high schools were asked about how they were preparing students who are taking computer aided design courses for the next level of college coursework with regard to construction, architecture, and/or civil design. Twelve of the 27 responded (44%).

As with industry, the same question was asked to the regional high schools: "What exactly is BIM?" 71 % considered BIM a 3D rendering tool where 29% felt it was a new Autodesk AutoCAD program. When ask to define BIM in greater detail, one of the regional high school described BIM as such: "It displays the structure as a 3D model but its main functionality is a massive data base where materials, vendors, etc. can be tracked and documented."

Table 2: CAD Capabilities at Regional High Schools (all that apply)

Answer Choices	**Responses**	
Auto Desk AutoCAD 2012 or older	12.50%	1
Auto Desk AutoCAD 2014	62.50%	5
Auto Desk Architecture 2012 or older	0.00%	0
Auto Desk Architecture 2014	37.50%	3
Auto Desk Revit	50.00%	4
Auto Desk 360	12.50%	1
Auto CAD Design Suite	12.50%	1
AutoCAD Civil 3D	25.00%	2
Sketch up	12.50%	1
Chief Architect	0.00%	0
SolidWorks	50.00%	4
Total Respondents: 8		

With regard to CAD capabilities, eight of 12 schools had some sort of CAD capability, five (62.5%) are using AutoCAD 2014 and four (50%) of those eight are using Revit. The five AutoCAD 2014 users also reported having Inventor. With the eight respondents having some

sort of CAD capabilities, half (four) were using SolidWorks. The remainder of software utilized at the high school level is expressed in Table 2.

4.2. Pilot Program Evaluation

4.2.1 Student Evaluation

Prior to start of the pilot program course, the instructor presented the students with a questionnaire to evaluate their experience and understanding of BIM theory and practice (Appendix F). The first part of the survey was based on students' knowledge of the construction industry and software. Student could score a maximum of 140 points. In taking his own survey the instructor scored 98 out of 140. The class average was 35, with the highest being 65 and lowest being 22. Students were asked to rank their knowledge of 3D modeling/Revit/BIM theory on a scale of 1 to 10, with 1 having low or no experience and 10 having the highest experience and understanding. On average, students' experience and understanding level was at 1.4 points. The same questionnaire was presented to students at the end of the course along with five short answer questions about their experience; the student understanding level increased by approximately 7.3 points. Based on the answers of the remaining four questions, the instructor's survey indicated that the use of Revit was the area of BIM the student gained the most knowledge in. Conversely, the area in which the least amount of knowledge was gained in was sustainable construction. Asked what area the students found most useful with regard to BIM functions and how it relates to Building Construction Management, the most popular answer was the ability to tie construction documents (schedule/estimate) to the 3D model. Lastly, when asked, students had trouble predicting how the knowledge and skill acquired during the course would be applicable and relevant in real world projects.

4.2.2 Instructor Evaluation

The Instructor for the pilot program is a seven year CAD professional who works at an architectural firm in the targeted region. He is the firms' resident technology expert. Prior to starting the course, the instructor participated in a four day Autodesk Revit and AutoCAD Architecture 2014 training conducted by Rock Valley College's technology provider. The training was designed to teach new features of AutoCAD Architecture and Revit 2014 along with their incorporation into a BIM environment.

A post-course review with the instructor determined that many aspects of the course pilot program were successful while other aspects needed revision to enhance the overall student learning experience. It was determined that preparation time for the initial pilot was adequate and the instructor felt well versed in the material and how it was to be presented.

The pilot class had an enrollment of 15 students. To best serve the needs and provide adequate instruction equally to all students, a class size with a maximum enrollment of 12 would be more conducive to learning. A follow-up idea with regard to student capacity was to separate lab from lecture. This would allow for smaller lab sections to support a larger lecture class. In the instructor's opinion, lecture and lab work best together because conducting practical applications of the concepts while they are being introduced is more conducive to long term retention of those concepts.

The resources available at the college in terms of equipment, space, and software (and version), met the needs of instruction. The college has the latest version of AutoCAD suite, with the predominate programs being Autodesk AutoCAD, Revit, and AutoCAD Architecture. If future development is deemed appropriate, then other software programs should be introduced.

There are desired prerequisites that the instructor felt were important for students to have in order to keep pace with the more advanced topic of BIM. Students should have a firm knowledge and comprehension of how to read and understand commercial project drawings/blueprints. This includes, but is not limited to, the architectural, civil, MEP, and structural sets of drawings. Students should also have a basic computer aptitude of how a computer operates, how to perform basic computer navigations, and how to access and utilize internet resources. Preferably a student should have previous CAD experience. Previous CAD experience is not necessary for mastering Revit or other 3D programs; more, it provides a foundation for critical thinking and the mastery of advanced topics.

In reviewing the breakdown of time spent in lecture, lab, and outside of class, the instructor believes that the most effective use of time would be to utilize one-and-a half hours of class period on lecture of concept and procedures. The remaining two hours would be dedicated to computer applications, project planning, and implementation. To truly master and excel at the theories and practices behind what makes BIM such a valuable tool, a student should spend another two hours on their project, further developing an understanding of the complexities that are involve in creating a BIM project/model.

In the instructors' opinion, the material introduced in the pilot course was a valuable beginning for further development of a more comprehensive BIM program at the community college level. However, for college students with limited industry and CAD experience, the course should be expanded to 16 weeks (in line with most college courses) to optimize learning. The eight week course can work when dealing with industry professionals. His opinion is that BIM is going to be important for the success and development of the construction industry in the Rock Valley College District 511 region.

4.2.3 Author's Survey

After the completion of the course the author/researcher for this study approached students who took the Fall 2013 eight-week course titled BCM 250: BIM Theory and Methods to gain an understanding of their impression of the course and to understand whether or not BIM is a topic that can be effectively integrated in a Building Construction Management program at the community college level. This enquiry was performed through an on-line survey that the students were under no obligation to take. The survey was open for 10 days which allowed students' to take the survey at their convenience. The survey contained 22 questions (Appendix G). There was a 27% response rate to the survey.

The first question on the survey asked the student to define BIM. Three-quarters of the responses centered on creating a better means of communicating and sharing information about a project. Prior knowledge of the concepts that are attributed to BIM and associated tools was very limited, with only 25 % of the respondents having any prior knowledge of BIM concepts before taking the course. Of those enrolled in the course, 75% had taken a previous course in AutoCAD and 50% of them felt it beneficial to have that experience prior to the introduction of the BIM: Theory and Method course. One student thought it provided minimal assistance in completing the BIM course successfully. In determining how BIM will contribute to their career search, one student thought it would be very helpful in finding a job, whereas three of the four thought it would be only somewhat beneficial. This perception is understandable based on the regional construction industry response to the role BIM would play in their business model which is presented later in this research. Contradictory to that premise, all but one of the students agreed that BIM will play an important role in the success of the construction industry in the Northern Illinois/Southern Wisconsin region.

With regard to pace of the course, only one of the students felt the pace was too quick. This would seem to correspond with a possible lack of knowledge in using CAD programs. Of the information presented during the course, 75% of the respondents felt the material covered was just right, while the remaining 25% thought it fell short of expectations. Half the students spent one to two hours a week working outside of class/lab on course assignments. One completed course assignments during designated class/lab time, while the final student spent three to four hours outside of class/lab sessions working on assignments. One student expressed the desire for more time to be spent on the theory portion of the curriculum whereas the remaining students felt the information covered provided enough theory as part of the curriculum. The majority who responded had hoped for more time to be spent on the Revit portion of the course, yet one felt the amount of time spent on Revit was adequate. When asked to evaluate the quality of instruction, three-quarters of the students labeled the instructor as very knowledgeable.

To better determine what BIM courses should be offered at the community college level, a section of survey addressed what the student felt was appropriate course work for the program. Because the most the institution can provide is a two year Associate in Applied Science degree, knowing what the student considers necessary course work for earning their degree was important. At the community college level, most are trying to complete the necessary general education requirements along with their Career and Technical Education (CTE) course work.

When asked about offering course work in Revit prior to introducing the concepts of BIM, two of the three that responded felt it would be better served that way. One student found it appropriate to combine and present the two together. All four who took the survey thought Revit and BIM theory were important elements that should be covered in the BCM program at Rock

Valley College. If BIM was presented as an elective and not part of the degreed curriculum, all students involved in the survey responded they would still take the course. All agreed that the Building Construction Management program should pursue a more comprehensive BIM curriculum, and would recommend the class to others in the program.

Half of the students in the study commented that at the conclusion of the course they understood the theory and methods of BIM as presented but still were not confident in applying it to a problem while the other half was comfortable with BIM concepts and how to apply them. When asked to identify which group in the construction industry would benefit most from BIM tools, all agreed its greatest benefit is to architects and engineers. Those that they thought would least benefit from BIM was unions, owners, and education.

5. CONCLUSIONS & RECOMMENDATIONS

5.1. Conclusions

Building Information Modeling is much more that a 3D modeling program. It cannot be purchased as a software suite. Nor can the software tools assembled make an individual a skilled technician. To develop an effective BIM program that trains students with skills that can be utilized in the construction industry, background knowledge of construction materials and methods, scheduling, estimating, and use of technology are a few of crucial element required. Sacks and Pikas (2013) state it more succinctly: BIM is a comprehensive means for managing information and conduction analysis of a project, a new way of thinking distinctive from CAD.

Post-secondary institutions, whether two or four year institutions, in the state of Illinois or Southern Wisconsin, struggle with finding a meaningful way to implement BIM tools and concepts into the curriculum. Multiple approaches are currently in practice. Some institutions offer a single course and label it as BIM. Others spread it through a group of courses. Yet a third philosophy incorporates the concepts across the entire program curriculum. Considerations about what type of degree or certificate are being conferred, the focus of the program, whether architecture or construction, also play a determining factor on how BIM integrates into the course work. When survey recipients were asked the best means of delivery of BIM training by Rock Valley College, the consensus (70%) was to offer it as stand-alone training but many (55%) of those surveyed also thought it appropriate to offer through a certificate program. Institutions feel additional pressure from accrediting organizations. Expanding the curriculum or modifying the course offerings may deviate from established requirements for accreditation.

The implementation of BIM in construction and related industries continues to increase. Results from a Jones and Bernstein's (2012) study shows that 71% of respondents have adopted

BIM for design, construction, and facilities operation in the United States. In the Rock Valley College District 511 region, the results show a much different trend. Although the sample size was small, contractors in the region are not realizing the benefits a strong BIM program can offer their organization through means of information management and project analysis. Architect and Engineering firms are embracing BIM as a tool to a greater degree, but it is not yet the predominant means of delivering a project.

Results from the Pilot program concluded that BIM theory and methods education is possible at the community college level. The extent of the education conducted will be the discussion in the Recommendations section of this paper. Four objectives and the scope of those objectives were defined as needing investigation for determining feasibility of BIM education at the community college. The first was to establish the prerequisites necessary for enrolling in the course. A review of the surveys and a post-course review identified the prerequisites necessary for improving the pace of the course and improving student comprehension of the subject matter: Commercial Blueprint Reading (BCM 104), Materials and Methods of Construction (BCM 117), Mechanical Systems (BCM 120), and Introduction to Architectural AutoCAD (BCM 137). The second objective investigated was whether or not a single course can adequately address both theory and basic application. The pilot program discovered is that a single course is able to introduce BIM theory along with the predominate tools necessary for a functional BIM program but may not be enough to fully engage a student in managing a project. Only half the students that responded to the survey felt that they were competent enough to take on a role of BIM technician. The third objective was to evaluate what facet of the construction industry would be is best served by BIM education at the community college. In referencing the surveys, the AE community is most engaged with BIM and the theories behind it. The college has had success in

the past with placing CAD technicians with Architectural firms; hopefully, with the proper BIM skills, this trend of successful student placement can continue. The general contracting community shows the most promise. With positive and increasing trends in adopting BIM outside of the Northern Illinois/Southern Wisconsin region, Rock Valley College is in a position to introduce the technology, tools and concepts of BIM in preparation for an eventual demand. Verification and documentation of the demand can be found throughout the literature review and symposium proceedings. The last objective of this research was to develop a curriculum that will satisfy the shortcoming identified in the BCM program review. Through the process of conducting this study, curriculum development will require greater and additional research.

5.2. Recommendations

It is possible to provide meaningful BIM education at the community college level. The current research findings indicate a number of areas are strategically in place for successful incorporation of BIM theories and methods into the BCM curriculum at Rock Valley College.

Additional studies will determine whether it is advantageous to add additional course(s) to the curriculum, replace existing course(s), or make modifications to existing course(s). To enhance BIM development, other courses in the program should be evaluated to determine to what extent course material is BIM related, and whether BIM can be effectively integrated while adhering to course learning objectives. A more comprehensive review of peer institutions will need to be conducted to analyze similarities and differences in the programs. This will allow for further recommendations. Working with the Advisory Committee and again consulting the collective industry and educational professionals, a determination of needs should be assessed for creating a BIM technician certificate, standalone training, or degree that industry values.

The finding of this study will be presented to the BCM Advisory Committee. The department will seek an endorsement from the group on the proceeding recommendation, and once endorsed, a proposal will be submitted to the College's Curriculum Committee and ICCB for adoption.

REFERENCES

Ahn, Y. H., Cho, C. S., and Lee, N., (2013). "Building information modeling: systematic course development for undergraduate construction students." *Journal of Professional Issues in Engineering Education and Practice,* 139, 290-300.

Aish, R. (1986): 'Building Modeling: The Key to Integrated Construction CAD', *CIB 5th International Symposium on the Use of Computers for Environmental Engineering Related to Buildings,* 7-9 July *Alexander, C., (1964). Notes of the synthesis of form.* Harvard University Press, Cambridge, Massachusetts.

Alexander, C. (1964). *Notes on the Synthesis of Form*. Harvard University Press.

Alfieri, L. (2012). Does Discovery-Based Instruction Enhance Learning? Journal of Educational Psychology, v103 n1 p1-18 Feb 2011. 18 pp.

Aly, S. (2014, January). Building information modeling (BIM) and its future in undergraduate architectural science capstone projects. In R.Issa (chair), the buildingSMART alliance: BIM Academic Symposium. Conducted at the National Institute of Building Science Conference & Expo's Building Innovation 2014, Washington, DC.

American Council for Construction Education, (2013). Document 103: Standards and Criteria for Accreditation of Postsecondary Construction Education Programs. Retrieved from http://acce-hq.org/index.htm.

ASCE. (2008). *Civil engineering body of knowledge for the 21st century: Preparing the civil engineer for the future,* Reston, Virginia.

Bawinkel, D. (2013). 2013 Building construction management program review. Unpublished report, Department of Building Construction Management, Rock Valley College, Rockford, Illinois.

Becerik-Gerber, B., Gerber, J., & Ku, K., (2011). The pace of technological innovation in architecture, engineering, and construction education: Integrating recent trends into the curricula. *Journal of International Technology in Construction, vol. 16,* 411-432.

Boon, J. and Prigg, C. (2011). *"Releasing the potential of BIM in construction education." Proc., Construction Industries Board Int. Conference on Management and Innovation for Sustainable Build Environment,* Delft University of Technology, Amsterdam, Netherlands, 9.

Center for Applied Special Technology, CAST (2012). The Three Principles. Retrieved from: http://www.udlcenter.org/aboutudl/whatisudl/3principles

Clark, R. E. Kirschner, P. A. & Sweller, J. (2012). Putting Students on the Path to Learning: The Case for Fully Guided Instruction, American Educator, v36 n1 p6-11 Spr 2012. 6

Clevenger, C., Ozebek, M., Glick, S., and Porter, D. (2010). *Integrating BIM in construction education.* Colorado State University, Fort Collins, CO.

Clevenger, C., Valdes-Vasquez, R. (2014, January). Teaching modules documenting the development of a center for virtual design and construction. In R. Issa (chair), the buildingSMART alliance: BIM Academic Symposium. Conducted at the National Institute of Building Science Conference & Expo's Building Innovation 2014, Washington, DC.

De Monchaux, N. (2011). *Fashioning apollo.* MIT Press, Spain.

Denzer, A. S., and Hedges, K. E. (2008). "From CAD to BIM: Educational strategies for the coming paradigm shift." *Proceedings, 2008 Architectural Engineering National Conference,* Denver, CO, 1-11.

http://www.dougengelbart.org/pubs/augment-3906.html# *SRI Summary Report AFOSR-3223. Prepared for: Director of Information Sciences, Air Force Office of Scientific Research, Washington 25, DC, Contract AF 49(638)-024.SRI Project No. 3578 (AUGMENT, 3906).*

www.educationnews.org/career-index/

Eastman, C., Lividini, J., and Stoker, D. A Database for Designing Large Physical Systems. , National Computer Conference and Exposition (1975) 603-611.

Eastman, C., Teicholz, P., Sacks, R., Liston, K. (2007): *The BIM Handbook* (1st Edition), John Wiley & Sons, New Jersey

Fellows, R., Liu, A. (2008). *Research methods for construction.* Blackwell Publishing, West Sussex, United Kingdom.

Gordon, C., Azambuja, M., and Werner, A. M. (2009). "BIM across the construction curriculum." *Associated Schools of Construction, Region III 2009 Conference, E. El-Gafy, ed., Southern Illinois University, Edwardsville, Illinois.*

Jones J, Mezo M, Warner J (2009) "Team Teaching the Capstone Construction Management Course: How and Why". *Proceedings of the 2009 ASC International Conference,* Gainesville, Florida

Jones, S., & Bernstein, H., (2012). *The Business Value of BIM in North America* (SmartMarket Report). New York, NY: McGraw-Hill Construction.

U.S. General Services Administration. (2011, June 5). Citing online source. *3D-4D building information modeling.* [WWW document]. URL http://www.gsa.gov/portal/category/21062

Hannafin, M., Land, S., and Oliver, K. (1999). Open learning environments: Foundations, methods, and models. In instructional design theories and models. vol. 2, ed. C. Reigeluth, 115–140. Mahlway, N.J.: Erlbaum.

Hardin, B. (2009). *BIM and Construction Management: Proven Tools, Methods, and Workflows.* Wiley Publishing, Indianapolis.

Harmann, T., and Fischer, M. (2008). "Applications of BIM and hurdles for widespread adoption of BIM." *2007 AISC-ACCL eConstruction Roundtable Event Report,* Stanford University, Stanford, CA.

Higher Education Opportunity Act (2008). Sec. 103. Additional Definitions- Universal Design for Learning. Retrieved from: http://www.gpo.gov/fdsys/pkg/PLAW-110publ315 /pdf/ PLAW-110publ315.pdf

Kymmell, W. (2008). *Building information modeling: Planning and managing construction projects with 4D CAD and simulation,* McGraw-Hill Professional.

Laiserin, J. (2002): 'Comparing Pommes and Naranjas', *The Laiserin Letter*, December 16, Issue 15

Learning and Information Technology Department, University of Wisconsin-Stout (2013). About the eStout program. Retrieved from: http://www.uwstout.edu/lit/es/index.cfm

Leedy, P. D., and Ormrod, J. E. (2013). *Practical research planning and design.* United States, Pearson.

Maghiar, M. (2014, January). The challenges of advancing BIM in the curriculum while addressing current accreditation standards for construction. In R. Issa (chair), the buildingSMART alliance: BIM Academic Symposium. Conducted at the National Institute of Building Science Conference & Expo's Building Innovation 2014, Washington, DC.

McCuen, T. (2014, January). Building information modeling (BIM) and its future in undergraduate architectural science capstone projects. In R. Issa (chair), the buildingSMART alliance: BIM Academic Symposium. Conducted at the National Institute of Building Science Conference & Expo's Building Innovation 2014, Washington, DC.

McHarg, I., L. (1969). *Design with nature.* Published for the American Museum of Natural History [by] the Natural History Press. Garden City, New York.

Nyman, J. S. (2001).What is Structured Discovery Learning? http://www.ncbvi.ne.gov/board/minutes/2006-minutes/2006-2-4/structured-discovery.html

PTAC, (2012, October). A Business Exchange for Construction Industry Professionals. In A. Johns (Chair), Illinois *Procurement Technical Assistance Center (PTAC) conference*. Symposium conducted at Rock Valley College, Rockford, Illinois.

Quirk, Vanessa. *"A Brief History of BIM / Michael S. Bergin" 07 Dec 2012. Arch Daily. Accessed 28 Feb 2015. <http://www.archdaily.com/?p=302490>*

Raphael, B. (2009) "Promoting efficient use of visualization tools through education." *Journal of Computing in Civil Engineering*, 23(6), 428-435.

Rock Valley College Catalog (2013-2014) https://www.rockvalleycollege.edu/Academics/upload/RVC-Catalog-2013-2014.pdf

Rodriquez, G. (2014, January). Universal design for learning (UDL) within an interdisciplinary course for building information modeling (BIM). In R. Issa (chair), the buildingSMART alliance: BIM Academic Symposium. Conducted at the National Institute of Building Science Conference & Expo's Building Innovation 2014, Washington, DC.

Ryles, R. (2008). Structured-Discovery Learning: What It Is and Why It Works. https://nfb.org/images/nfb/publications/bm/bm08/bm0807/bm080708.htm

Sabongi, F. J. (2009). *The integration of BIM in the undergraduate curriculum: An analysis of undergraduate courses,* Minnesota State University, Mankato, Minnesota.

Sacks, R., Pikas, E., (2013) "Building Information Modeling Education for Construction Engineering and Management. I: Industry Requirements, State of the Art, and Gap Analysis." Journal of Construction Engineering Management – ASCE Library.

Smith D (2007) "An Introduction to Building Information Modeling (BIM)". *Journal of Building Information Modeling.* Washington D.C. 12

Stock, M. (1985). *A practical guide to graduate research,* McGraw-Hill, United States.

Tatum, C. B. (2011). "Core elements of construction engineering knowledge for project and career success." Journal of Construction Engineering Management, 137(10), 745-750.

Taylor, M., Liu, J., and Hein, M. (2008) "Integration of building information modeling (BIM) into an ACCE accredited construction management curriculum. "*Proceedings, International Conference of the Associated Schools of Construction,* The Associated Schools of Construction, Windsor, CO.

Techsmith (2013) *Jing*. Retrieved from: http://www.techsmith.com/jing.html

Tyler, R. W. (1949). *Basic principles of curriculum and instruction,* University of Chicago Press, Chicago.

Van Nederveen, G.A. & Tolman, F. (1992), 'Modelling Multiple Views on Buildings', *Automation in Construction*, December, Vol 1, Number 3, pp215-224

WKU Undergraduate Catalog (2012-2013) (http://www.wku.edu/undergraduatecatalog/documents/12_13_catalog_files/wku_ugrad_catalog_12_13.pdf)

Wong, K. A., Wong, K. F., and Nadeem, A. (2011). "Building information modeling for tertiary construction education in Hong Kong." *ITcon – Journal of Information Technology in Construction,* 16, 467-476.

Woo, J. H. (2006). "BIM (building information modeling) and pedagogical challenges." *Proc., 43rd Associated Schools of Construction (ASC) National Annual Conference,* Western Illinois University, Macomb, Illinois, 12-14.

Xie, H., Boden-McGill, C.J. (2014, January). Encouraging students involvement through structured discovery learning strategy in teaching BIM courses. In R. Issa (chair), the

buildingSMART alliance: BIM Academic Symposium. Conducted at the National Institute of Building Science Conference & Expo's Building Innovation 2014, Washington, DC.

Young, N. W., Jones, S. A., and Bernstein, H. M. (2008). *Building information modeling (BIM): Transforming design and construction to achieve greater industry productivity.* McGraw-Hill, New York.

Young, N. W., Jones, S. A., Bernstein, H. M., and Gudgel, J. (2009a). "SmartMarket report on Building Information Modeling (BIM): Transforming design and construction to achieve greater industry productivity." McGraw-Hill Construction, New York.

Young, N. W., Jones, S. A., Bernstein, H. M., and Gudgel, J. (2009b). *The business value of building information modeling: Getting building information modeling to the bottom line*, McGraw-Hill, New York.

APPENDIX A. CONSTRUCTION PROFESSIONAL SURVEY

Northern Illinois and Southern Wisconsin Construction Industry Professionals

1. Were you or your company aware that Rock Valley College offers an Associate in Applied Science degree in Building Construction Management?
Yes
No

2. Were you or your company aware that Rock Valley College offers an Associate in Applied Science degree in Sustainable Building Science?
Yes
No

3. Were you or your company aware the Rock Valley College offers certificates in different disciplines of Building Construction Management and/or Sustainable Building Science?
Yes
No

4. What AutoCAD capabilities does your company current have? Please select all that apply.
Auto Desk Architecture 2012 or older
Auto Desk Architecture 2014
Auto Desk Revit
Auto Desk 360
Auto CAD Design Suite
AutoCAD Civil 3D
Sketch up
Chief Architect
SolidWorks
Other (please specify)

5. What other design software does your company support?
Bluebeam
Navisworks
Microsoft Project
Sage Suite
Inventor
Other (please specify)

6. Which of the following descriptions is your best understanding of what BIM (Building Information Modeling) is.
A 3-D rendering Program
A new AutoCAD suite from Autodesk
Other (please specify)

7. What best describes your business model?
Commercial General Contractor
Residential General Contractor
Municipality
MEP contractor
Building Architectural Firm
Landscape Architectural Firm
Civil Engineering Firm
Material Supplier
Product Manufacturer
Fabricator
Non-profit
Skilled Trade organization
Other (please specify)

8. What percent of your business is...?

Bid	0% to 24%	25% to 49%	50% to 74%	75% to 100%
Negotiated	0% to 24%	25% to 49%	50% to 74%	75% to 100%

Other (please specify)

9. Have you considered developing a BIM program within your organization?
Yes
No
We currently have BIM capabilities in-house.

10. If you answered No to the previous question, what would be a motivating factor to consider adding the capability to your organization? Please check all that apply.
Capabilities required by private owners
Capabilities required by local municipalities
Capabilities required by Government Services Administration
Other (please specify)

11. If BIM capabilities were required in your organization, what minimum qualifications would you require for this position? Please select more than one if applicable.
Send current personnel to training.
Bachelor's degree
Graduate degree
Associates degree
A degree isn't necessary; BIM experience is more important.
We would sub-contract the process out to others.
Other (please specify)

12. Would your organization consider Rock Valley College for providing the BIM training?
Yes
No
(Please explain)

13. How would you like to see this training delivered? Check all that apply.
Part of the degree program as a 16 week course.
Part of the degree program as an accelerated 8 week course.
As part of the certificate program.
As a stand-alone training through adult or continuing education.
Other (please specify)

14. If the Building Construction Management and Sustainable Building Science department at Rock Valley College held an information meeting to present the programs and seek your input on improving the programs, would you or someone from your company attend?
Yes
No

15. If you answered No to the previous question, could you provide insight into what may stir your interest to participate?

16. Are there any additional comments you would like to make about the BCM or SBS programs, or BIM education at RVC?

17. Could you please provide three requirement needs for a BIM professional in your organization?
First
Second
Third

18. Has a client asked you about your ability to perform a project in BIM?
Yes
No

19. Has another construction professional asked about your BIM capabilities?
Yes
No
If so, which industry partner?

20. If you answered yes to the previous question, how many inquiries have you had?
0 to 3
4 to 7
8 to 10
No inquirers

21. If you currently have an in-house program, how long have you had it?
0 to 3 years
4 to 7 years
8 to 10 years
No program

APPENDIX B. HIGH SCHOOL SURVEY

Regional High Schools

1. Were you or your school aware that Rock Valley College offers an Associate in Applied Science degree in Building Construction Management?
Yes
No

2. Were you or your school aware that Rock Valley College offers an Associate in Applied Science degree in Sustainable Building Science?
Yes
No

3. Were you or your school aware the Rock Valley College offers certificates in different disciplines of Building Construction Management and/or Sustainable Building Science?
Yes
No

4. What AutoCAD capabilities does your school current have? Please select all that apply.
Auto Desk Architecture 2012 or older
Auto Desk Architecture 2014
Auto Desk Revit
Auto Desk 360
Auto CAD Design Suite
AutoCAD Civil 3D
Sketch up
Chief Architect
SolidWorks
Other (please specify)

5. What other design or building software does your institution support?
Bluebeam
Navisworks
Microsoft Project
Sage Suite
Inventor
Other (please specify)

6. Which of the following descriptions is your best understanding of what BIM (Building Information Modeling) is.
A 3-D rendering Program
A new AutoCAD suite from Autodesk
Other (please specify)

7. Have you considered developing a BIM program within your organization?
Yes
No
We currently have BIM capabilities in-house.

8. Would your organization consider teaming Rock Valley College for providing the BIM training?
Yes
No
(Please explain)

9. How would you like to see this training delivered? Check all that apply.
Part of the degree program as a 16 week course.
Part of the degree program as an accelerated 8 week course.
As part of the certificate program.
As a stand-alone training through adult or continuing education.
Other (please specify)

10. If the Building Construction Management and Sustainable Building Science department at Rock Valley College held an information meeting to present the programs and seek your input on improving the programs, would you or someone from your company attend?
Yes
No

11. If you answered No to the previous question, could you provide insight into what may stir your interest to participate?

12. Are there any additional comments you would like to make about the BCM or SBS programs, or BIM education at RVC?

13. Has a client asked you about your ability to perform a project in BIM?
Yes
No

14. Has another construction professional asked about your BIM capabilities?
Yes
No
If so, which industry partner?

15. If you answered yes to the previous question, how many inquiries have you had?
0 to 3
4 to 7
8 to 10
No inquirers

16. If you currently have an in-house program, how long have you had it?

0 to 3 years

4 to 7 years

8 to 10 years

No program

APPENDIX C. COURSE LEARNING OUTCOME RUBRIC

Rubric Components	Point Scale				Program's Score
	4	3	2	1	
Analytic Reasoning Students will form logical inferences, judgments, or conclusions from facts, or premises related to topics encountered in the classroom.	Thorough and accurate understanding of what BIM is and how it applies to the construction industry	Connectivity between BIM and construction industry developed using prior foundations	Minimal conclusion of facts with regard to BIM theory because of inadequate previous process development	Inability to identify logical connection between BIM theory and methods and construction industry applications.	3
Global Awareness & Responsibility Students will develop the knowledge and skills required to responsibly interact with social and natural communities, both locally and globally.	Thorough and accurate understanding of BIM's contributions to sustainable building practices and global effects of the built environment	Realization of how BIM can improve the effects of construction on the environment	Understand BIM is a tool used to communicate the requirements of a building project to the project team	Sees BIM as a design tool to create contract documents	2
Communication Students will exchange ideas effectively in a variety of settings.	Thorough and accurate expression of concepts or ideas through use of BIM theories and applications	Ideas exchanged require additional dialog to be thoroughly effective	Expression of concepts of ideas through BIM limited by ignorance of theories or applications	Inability to communicate specific concepts or ideas using BIM theory or other CAD related functions	3

APPENDIX D. STUDENT LEARNING OUTCOME FOR BCM 250 COURSE PROJECT

Components	Point Scale				Score
	4	3	2	1	
Critical Thinking Identifies BIM project requirements based on general descriptions and instructor requirements.	Thorough and accurate understanding of BIM project requirements.	General understanding of the BIM project requirements.	Minimal comprehension of the BIM project requirements.	Inability to identify BIM project requirements.	
Integrate technology into all fields of knowledge and expression.	Thorough and accurate understanding of how Revit is incorporated to meet the desired project outcome.	Functional ability to understand and use Revit.	Ability to understand and use basic Revit functions.	Inability to use basic Revit applications.	
Communication Students will exchange ideas effectively in a variety of settings.	Thorough and accurate expression of project concepts or ideas through use of BIM theories and applications.	Ideas introduced on BIM project require additional detail to be thoroughly effective.	Expression of project requirements or concepts through BIM limited by ignorance of theories or applications.	Inability to communicate specific project requirements or concepts using Revit or other BIM related functions.	

APPENDIX E. COURSE SYLLABUS

ROCK VALLEY COLLEGE
Division of Engineering and Technology

Building Construction Management

INSTRUCTOR INFORMATION –

Jacob Addis
Phone: 815.963.1900 Division Office: 815.921.3101
jaddis@gwaarchitects.com or though EAGLE Office hours: 5:00pm -6:00pm

FSO (Faculty Support Office) information: WTC 202

BCM 250 – INTRODUCTION TO BIM: THEORY AND PRACTICE PCS* Code – 1.2

IAI: None

COURSE DESCRIPTION -- This course will expose the student to the theory, principles, and practices needed to understand Building Information Modeling (BIM) practice as related to the construction industry. The range of topics to be discussed include: what is BIM, how does BIM apply to the different facets of the construction industry, tools needed to implement, along with introduction to the use of Revit. This course is offered as a hybrid where the class will meet once a week and the student will be required to follow Eagle (canvas) for additional instructions and submission of work.

PREREQUISITE: None
CREDITS: 3 **Lecture:** 2 **Lab: 2**

Method(s) of Delivery (mark all that apply): Face to Face_____ Online_____ Hybrid__X___

STUDENT LEARNING OUTCOMES –
This course addresses the following student learning outcome(s). The student will be able to:

X	Communicate effectively.
X	Integrate technology into all fields of knowledge and expression.
X	Demonstrate competency in critical thinking.
	Respect and work effectively with persons of diverse backgrounds and abilities.
	Demonstrate the behaviors of ethical and socially responsible citizens.
	Demonstrate personal wellness.

COURSE OBJECTIVES –

- Exhibit an understanding of what BIM is and how it applies to the construction industry.
- Identify the different element necessary to create the BIM process for different facets of the construction industry.
- Perform basic navigation through Revit software as it would apply to BIM.
- Execute a simple project using BIM.

COURSE TOPIC OUTLINE –

- Week 1: Introduction, Strategy, Online (Eagle), Student experience feedback, Q&A.
- Week 2: Construction Processes, Design-Bid-Build, Design-Build, BIM. Its advantages, downfalls. Areas for improvement. Why it's hard to start BIM. Why is the building construction industry already leaning towards BIM?
- Week 3: Architectural terminology, BIM: Pre-construction, Construction, Updates, Post-construction, facilities Management. BIM software, industry standards.
- Week 4: Autodesk AutoCAD – its uses, its advantages, its downfalls. Autodesk Architecture - its uses, its advantages, its downfalls. How it starts to incorporate BIM to AutoCAD as a stepping stone for the building construction industry.
- Week 5: Intro to Autodesk Revit. Show users the similarity to ACAD, but its difference in project approach. Explain advantages, downfalls. Explain Basic navigation, and basic commands.
- Week 6: finish Intro in to Autodesk Revit. Explain small project and get students started. Students to use lab time.
- Week 7: Use class time to work on small project, Students and instructor to work out Revit issues together. Instructor to help with any issues or conflicts.
- Week 8: Final project is due. Answer any questions and solve any outstanding issues.

SCHEDULE OF COURSE ACTIVITIES –

- August 27, 2013 *last day for tuition refunds*
- September 16, 2013 *Midterm*
- September 27, 2013 *last day to withdraw with a "W"*
- October 7, 2013 *last day of class*

COURSE GRADING -- *A description of the factors that affect student grades in the course, such as:*

- *Two course assignments 10% each*
- *Two quizzes 10% each*
- *Attendance 5%*
- *One large final project 50%*

REQUIRED READING AND SUPPLIES –

- *No book required; any manual through Autodesk of Revit will be helpful.*
- *8G flash drive required*

COLLEGE POLICY ON ACADEMIC HONESTY STANDARDS AND PROCEDURES

Academic Honesty Statement:

The faculty and administration expect that RVC students are enrolled in courses as serious and honorable scholars. Furthermore, students are expected to do their own, original work, except when collaboration on projects is directed by faculty as part of the course or specific assignment. Students are expected to observe the commonly accepted standards of academic honesty at all times.

Students who commit any of the forms of academic dishonesty as outlined in the ***RVC Student Handbook*** are subject to the penalties and sanctions agreed upon by the Faculty and Administration of Rock Valley College. Detailed procedures regarding academic dishonesty are given in the RVC Student Handbook. In addition to the penalty assigned by a faculty member, a report of the alleged violation and assigned penalty will be made to the Office of Student Judicial Affairs.

NOTIFICATION OF SERVICES FOR STUDENTS WITH DISABILITIES

If you have a documented disability and would like to request accommodation and/or academic adjustments, please contact the Disability Support Services Section 504 Coordinator. You should contact the coordinator as soon as a need for accommodation is known so that implementation can occur as soon as possible. The Disability Support Services Office is on the second floor of the Student Center. The telephone number for this office is 815-921-2356 v/tty.

ELECTRONIC DEVICES POLICY

During class there should be:

- NO cell phones (Turn OFF or put on vibrate)
- NO text messaging
- NO iPods or other such devices
- NO other electronic devices unless agreed to by the instructor

Students must request permission from the instructor to use a recording device or laptop computer.

Cell phones and electronic devices must be turned OFF (or put on vibrate for cell phone) and placed out of sight (in pocket, backpack, purse).

DISCLAIMER

Instructor reserves the right to alter or change the elements within this syllabus.

APPENDIX F. INSTRUCTOR QUESTIONNAIRE

BCM – 250

Introduction to BIM – Theory and Practice

Experience Questionnaire

Please provide experience level for each subject. Use a scale of 1-10, 1 being the lowest, or no experience, 10 having the highest experience and understanding.

1. Residential Construction _____
2. Commercial Construction _____
3. Architecture _____
4. Engineering _____
5. Manufacturing _____
6. Design- Bid- Build Process _____
7. Design- Build Process _____
8. Building Information Modeling _____
9. Energy efficiency/ Building Performance Modeling _____
10. Sustainable Building (LEED, Energy Star) _____
11. Autodesk Auto CAD- *Software* _____
12. Autodesk Architecture- S*oftware* _____
13. Autodesk Revit- *Software* _____
14. Google Sketch-up- *Software* _____

Please total your answers Total: _____

Please answer questions on reverse.

1. At the beginning of class, you took the same survey. Do you think your understanding of BIM gained any points? If so, how many?

   _____

   _____

   _____

2. What area of BIM do you have the most understanding of? Please explain.

   _____

   _____

   _____

3. What area of BIM do you have the least understanding of? Please explain.

   _____

   _____

   _____

4. What areas of BIM do you find the most useful in regards to the BCM program at RVC?

   _____

   _____

   _____

5. After completing this course, do you think you have obtained any knowledge or skills that will be applicable and relevant in real world projects? Explain why or why not.

   _____

   _____

   _____

APPENDIX G. AUTHOR QUESTIONNAIRE

BCM 250: BIM Theory and Method

College of Engineering
Department of Construction Management and Engineering
NDSU Dept. 2475, PO Box 6050
Fargo, ND 58108-6050
701.231.7879

NDSU NORTH DAKOTA STATE UNIVERSITY

BCM 250: BIM Theory and Methods Students,
As you were aware of, the 8 week BCM 250: BIM Theory and Methods class you participated in Fall of 2013 was a pilot class to understand the effectiveness of Rock Valley Colleges' ability to successfully introduce Building Information Modeling theory and methods through a two year community college setting. Since completing the course I look to you for an honest evaluation of your experience taking the BCM 250 class. The attached survey consists of 22 questions and should take no longer than 5 minutes to complete. Your participation in this survey is voluntary and at any time during the survey you chose not to continue, please know you can do so without penalty or loss of benefits to which you are already entitled.
Be assured your name or identifying information will be kept anonymous and not distributed, displayed, or provided to others. The BCM department simply is interested in creating a better course and program.
As an aggregate, I will be incorporating this information with a considerable amount of additional information as research for evaluation (through a Masters Paper) by the Graduate Department at North Dakota State University. If you have any questions about the survey please do not hesitate to contact me. I can be reached at:
Dan Bawinkel
Office: G19, Rock Valley College - Woodward Technology Center - Main Campus, or
Phone: 815.921.3172, or
Email: d.bawinkel@rockvalleycollege.edu

BCM 250: BIM Theory and Method, Student Survey

1. Please provide your definition of BIM.

2. What was your knowledge of BIM prior to taking the course?
I knew nothing about BIM.
I knew the theory behind BIM.
I knew the theory and some methods in using BIM.
I was very familiar with BIM, its theory and methods.

3. What was your level of knowledge of AutoCAD prior to taking this class?
I was new to AutoCAD.
I had AutoCAD class (es) in high school.
I had one semester of AutoCAD at RVC.
I had two semesters of AutoCAD at RVC.
I have had AutoCAD at another college or university.
I use AutoCAD in my current career.

4. Did your previous AutoCAD experience benefit you in taking this course?
Made it more confusing.
Was no help.
Helped a little bit.
Was very helpful.
N/A

5. Will knowledge of BIM be useful in your career search?
Will not help.
Somewhat helpful.
Will be very helpful.

6. How was the pace of instruction during the class?
Way too slow.
Pace was good.
Way too fast.

7. How would you rate the amount of material covered during the class?
Fell short of expectations.
Just right.
Way too much.

8. How much time per week did you spend outside of class working on the assignments?
1 - 2 hours.
3 - 4 hours.
More than 4 hours.
I was able to do my assignments during lab time.

9. Was the time spent on BIM theory in the class appropriate?
Too much theory.
Just enough theory.
Too little theory.

10. Was the time spent on BIM methods (Revit) appropriate?
Too much method.
Just enough method.
Too little method.

11. Should RVC offer a class in Revit prior to introducing BIM?
Yes
No

12. In your opinion, what should the BCM program concentrate more on?
Select three.
Basic AutoCAD.
Advanced AutoCAD.
Revit.
Sketch-up.
Chief Architect.
BIM theory.

13. If the BIM class was only offered as an elective, would you be inclined to take it?
Yes
No

14. If Revit was only offered as an elective in the program, would you be inclined to take it?
Yes
No

15. How would you rate your understanding of BIM having taken the class?
I still don't understand what BIM is.
I understand the theory but lack knowledge on the methods to implement it.
I understand Revit, but don't understand the theory behind BIM.
I understand both theory and method, but not confident in applying BIM to a problem.
I am comfortable with what BIM is and how to use it.
Explain

16. Having taken the class, name three things that should be added to improve the class.
One
Two
Three

17. Rate the instructor's knowledge of BIM.

Had no knowledge
Very little knowledge
Seemed knowledgeable
Very knowledgeable

18. Which industry(s) can benefit from an individual who has knowledge of the BIM process? Select all that apply.
Commercial General Contractor
Architect/Engineer
Supplier Chain
Subcontractors
Material Manufacturer
Building Officials
Owners
Skilled Labor
Unions
Facility Managers
Utility Companies
Home Builders
Education
Other (please specify)

19. Should RVC explore developing a more comprehensive BIM program?
Yes
No
Other (please specify)

20. Would you recommend others in the program take this class?
Yes
No
(Please explain why or why not)

21. Is BIM important for the success of the construction industry in our region?
Yes
No
(Please explain)

22. What other comments would you like to make about your experience in BCM 250: BIM Theory and Methods?

APPENDIX H. IRB APPROVAL LETTER

NDSU NORTH DAKOTA STATE UNIVERSITY

November 5, 2014

Dr. Jerry Gao
Construction Management & Engineering

Re: IRB Certification of Exempt Human Subjects Research:
Protocol #EN15061 , "BIM Education in the Community College"

Co-investigator(s) and research team: Daniel Bawinkel

Certification Date: 11/5/14 Expiration Date: 11/4/17
Study site(s): varied
Sponsor: n/a

The above referenced human subjects research project has been certified as exempt (category # 2) in accordance with federal regulations (Code of Federal Regulations, Title 45, Part 46, Protection of Human Subjects). This determination is based on the revised protocol submission (received 11/3/14).

Please also note the following:
- If you wish to continue the research after the expiration, submit a request for recertification several weeks prior to the expiration.
- The study must be conducted as described in the approved protocol. Changes to this protocol must be approved prior to initiating, unless the changes are necessary to eliminate an immediate hazard to subjects.
- Notify the IRB promptly of any adverse events, complaints, or unanticipated problems involving risks to subjects or others related to this project.
- Report any significant new findings that may affect the risks and benefits to the participants and the IRB.

Research records may be subject to a random or directed audit at any time to verify compliance with IRB standard operating procedures.

Thank you for your cooperation with NDSU IRB procedures. Best wishes for a successful study.
Sincerely,
Kristy Shirley

Kristy Shirley, CIP, Research Compliance Administrator

For more information regarding IRB Office submissions and guidelines, please consult www.ndsu.edu/irb. This Institution has an approved FederalWide Assurance with the Department of Health and Human Services: FWA00002439.

INSTITUTIONAL REVIEW BOARD
NDSU Dept 4000 | PO Box 6050 | Fargo ND 58108-6050 | 701.231.8995 | Fax 701.231.8098 | ndsu.edu/irb

Shipping address: Research 1, 1735 NDSU Research Park Drive, Fargo ND 58102

APPENDIX I. ILLINOIS COMMUNITY COLLEGES

		Degree			Certificate			Software				
Illinois Community College Districts	City	Arch	CM	Drafting	Arch Dft.	CM	Drafting	AutoCAD	Revit	3D*	BIM	Notes
Black Hawk College,	Moline											
City Colleges of Chicago												
Richard J. Daley College												
Kennedy-King College												
Malcolm 1 College												
Olive-Harvey College												
Harry S. Truman College				1			1	1				
Harold Washington College		1								1		
Wilbur Wright College		1			1					1		
Danville Area Community College,	Danville											
College of DuPage,	Glen Ellyn	1			1			1	1		1	
East St. Louis Community College Center,	East St. Louis											
Elgin Community College,	Elgin						1	1	1			
Harper College,	Palatine	1			1			1	1		1	
Heartland Community College,	Normal			1			1	1	1			
Highland Community College,	Freeport											
Illinois Central College,	East Peoria		1				1	1		1		
IL Eastern Community Colleges												
Frontier Community College,	Fairfield											
Lincoln Trail College,	Robinson											
Olney Central College,	Olney											
Wabash Valley College,	Mt. Carmel											
IL Valley Community College,	Oglesby			1			1	1				
Joliet Junior College,	Joliet	1			1			1	1	1		
Kankakee Community College,	Kankakee			1			1	1	1		1	
Kaskaskia College,	Centralia			1			1	1		1		
Kishwaukee College,	Malta			1			1	1		1		
College of Lake County,	Grayslake			1			1	1		1		
Lake Land College,	Mattoon		1			1		1				
Lewis & Clark Community College,	Godfrey	1			1			1	1	1		
Lincoln Land Community College,	Springfield	1					1	1	1	1		
John A. Logan College,	Carterville		1					1				
McHenry County College,	Crystal Lake		1		1			1	1		1	
Moraine Valley Community College,	Palos Hills				1			1	1			
Morton College,	Cicero			1			1	1		1		
Oakton Community College,	Des Plaines			1			1	1	1	1	1	
Parkland College,	Champaign		1					1	1	1		
Prairie State College,	Chicago Heights						1	1				
Rend Lake College,	Ina	1			1			1		1		
Richland Community College,	Decatur			1			1	1		1		
Rock Valley College,	Rockford		1					1	1		1	
Carl Sandburg College,	Galesburg											
Sauk Valley Community College,	Dixon											
Shawnee Community College,	Ullin											
South Suburban College,	South Holland		1				1	1				
Southeastern Illinois College,	Harrisburg											
Southwestern Illinois College,	Belleville		1			1		1	1		1	*Bim Degree*
Spoon River College,	Canton											
Triton College,	River Grove	1			1			1	1		1	*Bim Degree*
Waubonsee Community College,	Sugar Grove			1			1					
John Wood Community College,	Quincy			1			1	1				
Morrison Institute of Technology*	Morrison			1				1		1		
	Totals	9	8	13	9	2	17	30	15	15	8	
Total schools with degree	30											
total schools with Certificates	28											
50 recongnized 2yr institutions												
* represents private 2yr school outside ICCB												

APPENDIX J. ILLINOIS FOUR-YEAR INSTITUTIONS

		Degree			Software			
Illinois Four Year Institutions	**Department**	**Arch**	**CM**	**CAD**	**CAD**	**Revit**	**3D**	**BIM**
Chicago State University								
Eastern Illinois University	AET, Construction		1		1			
Governors State University								
Illinois State University	Technology	1				1		1
Northeastern Illinois University								
Northern Illinois University								
Southern Illinois University Carbondale	TRM, Architecture	1					1	
Southern Illinois University Edwardsville	CM	1				1	1	1
U of I at Chicago	Architecture, *no cad listed*							
U of I at Springfield								
U of I at Urbana/Champaign	Architecture	1					1	1
Western Illinois University	Engineering Technology	1					1	1
Augustana College								
Blackburn College								
Bradley University	Construction	1						1
Eureka College								
Greenville College								
Illinois Baptist College								
Illinois College								
Illinois Wesleyan University								
Knox College								
Lincoln Christian University								
Lincoln College								
MacMurray College								
McKendree University								
Methodist College								
Millikin University								
Monmouth College								
Olivet Nazarene University								
Principia College								
Quincy University								
Rockford University								
St. Johns College								
Aurora University								
Benedictine University								
Christian Life College								
Concordia University								
Dominican University								
Elmhurst College								
Judson University	School of Architecture	1					1	
Knowledge Systems Institute								
Lake Forest College								
Lake Forest Graduate School of Mgmt.								
Lewis University								
Midwestern University								
North Central College								
Northwestern University								
Resurrection University								
Trinity Christian College								
Trinity International University								

		Degree			Software			
Illinois Four Year Institutions	**Department**	**Arch**	**CM**	**CAD**	**CAD**	**Revit**	**3D**	**BIM**
Univ. of St. Mary of the Lake								
University of St. Francis								
Wheaton College								
Columbia College Chicago								
DePaul University								
East-West University								
Erikson Institute								
Illinois Institute of Technology	Architecture	1					1	1
Loyola University of Chicago								
MacCormac College								
National-Louis University								
North Park University								
Realtor University								
Robert Morris University-Illinois								
Roosevelt University								
Rush University								
Shimer College								
St. Augustine College								
St. Xavier University								
Toyota Technological Institute at Chicago								
University of Chicago								
Midstate College								
Rockford Career College								
Vatterott College								
American InterContinental University Online								
DeVry University-Illinois								
Lincoln College of Technology								
Northwestern College-Southwest								
Solex College								
The Illinois Institute of Art-Schaumburg								
The Illinois Institute of Art-Tinley Park								
Westwood College-DuPage	Construction Management			1		1	1	1
Westwood College-River Oaks	Construction Management			1		1	1	1
American Academy of Art								
Coyne College								
Harrington College of Design								
Kendall College								
Midwestern Career College								
Northwestern College-Chicago								
Sanford Brown College - Chicago								
The Illinois Institute of Art-Chicago								
Tribeca Flashpoint Media Arts Academy								
Westwood College-Chicago Loop	Construction Management			1		1	1	1
Westwood College-O'Hare Airport	Construction Management			1		1	1	1
Totals		8	1	4	1	6	10	10
13 - 4 yr. schools in IL have targeted programs								
All targeted schools have CAD as a minimum								
94 recognized 4yr schools in IL								
Schools shadowed do not offer target programs								

APPENDIX K. WISCONSIN POST-SECONDARY INSTITUTIONS

Wisconsin Post-Secondary Institutions	Location	Degree	Cert.	Revit	3D	BIM	Type	Degree
Alverno College	Milwaukee						Private not-for-profit	Master's university
Bellin College	Green Bay						Private not-for-profit	Special-focus institution
Beloit College	Beloit						Private not-for-profit	Baccalaureate college
Blackhawk Technical College	Janesville						Public	Associate's college
Bryant & Stratton College–Milwaukee	Milwaukee						Private for-profit	Associate's college
Bryant & Stratton College–Wauwatosa	Wauwatosa						Private for-profit	Baccalaureate/associate's college
Cardinal Stritch University	Milwaukee						Private not-for-profit	Doctoral/research university
Carroll University	Waukesha						Private not-for-profit	Master's university
Carthage College	Kenosha						Private not-for-profit	Baccalaureate college
Chippewa Valley Technical College	Eau Claire						Public	Associate's college
College of Menominee Nation	Keshena						Private not-for-profit	Tribal college
Concordia University Wisconsin	Mequon						Private not-for-profit	Master's university
DeVry University–Wisconsin	Milwaukee						Private for-profit	Special-focus institution
Edgewood College	Madison						Private not-for-profit	Doctoral/research university
Fox Valley Technical College	Appleton						Public	Associate's college
Gateway Technical College	Kenosha	1		1		1	Public	Associate's college
Globe University–Eau Claire	Eau Claire						Private for-profit	Associate's college
Herzing University	Madison						Private for-profit	Baccalaureate/associate's college
High-Tech Institute–Brookfield	Brookfield						Private for-profit	Associate's college
ITT Technical Institute–Green Bay	Green Bay						Private for-profit	Special-focus institution
ITT Technical Institute–Greenfield	Greenfield						Private for-profit	Special-focus institution
ITT Technical Institute–Madison	Madison	1	1		1		Private for-profit	Associate's college
Kaplan College	Milwaukee						Private for-profit	Associate's college
Lac Courte Oreilles Ojibwa Community College	Hayward						Public	Tribal college
Lakeland College	Plymouth						Private not-for-profit	Master's university
Lakeshore Technical College	Cleveland						Public	Associate's college
Lawrence University	Appleton						Private not-for-profit	Baccalaureate college
Madison Area Technical College	Madison	1	1	1	1		Public	Associate's college
Madison Media Institute	Madison						Private for-profit	Associate's college
Maranatha Baptist University	Watertown						Private not-for-profit	Baccalaureate college
Marian University	Fond du Lac						Private not-for-profit	Master's university
Marquette University	Milwaukee	1		1		1	Private not-for-profit	Doctoral/research university
Mid-State Technical College	Wisconsin Rapids, Stevens Point						Public	Associate's college
Milwaukee Area Technical College	Milwaukee	1		1		1	Public	Associate's college
Milwaukee Institute of Art & Design	Milwaukee	1		1	1		Private not-for-profit	Special-focus institution
Milwaukee School of Engineering	Milwaukee	1	1	1		1	Private not-for-profit	Master's university
Moraine Park Technical College	Fond du Lac						Public	Associate's college
Mount Mary University	Milwaukee						Private not-for-profit	Master's university
Nashotah House	Nashotah						Private not-for-profit	Special-focus institution
Nicolet Area Technical College	Rhinelander						Public	Associate's college
Northcentral Technical College	Wausau						Public	Associate's college
Northeast Wisconsin Technical College	Green Bay						Public	Associate's college
Northland College	Ashland						Private not-for-profit	Baccalaureate college
Northland International University	Dunbar						Private not-for-profit	Baccalaureate college
Ottawa University–Milwaukee	Brookfield						Private not-for-profit	Baccalaureate college
Rasmussen College–Green Bay	Green Bay, Appleton, Wausau						Private for-profit	Associate's college
Ripon College	Ripon						Private not-for-profit	Baccalaureate college
St. Norbert College	De Pere						Private not-for-profit	Baccalaureate college
Sanford-Brown College	West Allis	1				1	Private for-profit	Associate's college
Silver Lake College	Manitowoc						Private not-for-profit	Baccalaureate college
Southwest Wisconsin Technical College	Fennimore						Public	Associate's college
University of Phoenix–Madison Campus	Madison						Private for-profit	Special-focus institution
University of Phoenix–Milwaukee Campus	Brookfield						Private for-profit	Special-focus institution
University of Wisconsin–Eau Claire	Eau Claire						Public	Master's university
University of Wisconsin–Green Bay	Green Bay						Public	Master's university
University of Wisconsin–La Crosse	La Crosse						Public	Master's university
University of Wisconsin–Madison	Madison	1		1		1	Public	Research university
University of Wisconsin–Milwaukee	Milwaukee						Public	Research university
University of Wisconsin–Oshkosh	Oshkosh						Public	Master's university
University of Wisconsin–Parkside	Kenosha						Public	Baccalaureate college
University of Wisconsin–Platteville	Platteville	1	1				Public	Master's university
University of Wisconsin–River Falls	River Falls						Public	Master's university
University of Wisconsin–Stevens Point	Stevens Point						Public	Master's university
University of Wisconsin–Stout	Menomonie	1					Public	Master's university
University of Wisconsin–Superior	Superior						Public	Master's university
University of Wisconsin–Whitewater	Whitewater						Public	Master's university
Viterbo University	La Crosse						Private not-for-profit	Master's university
Waukesha County Technical College	Pewaukee						Public	Associate's college
Western Technical College	La Crosse						Public	Associate's college
Wisconsin Indianhead Technical College	Shell Lake						Public	Associate's college
Wisconsin Lutheran College	Milwaukee						Private not-for-profit	Baccalaureate college
Totals		11	4	7	3	6		
23 schools in target market								
11 schools have target programs								
All target programs have a minimum of CAD								
Schools shadowed do not offer target programs								

APPENDIX L. VITA

Daniel V. Bawinkel is the Academic Chairperson and fulltime Assistant Professor for the Building Construction Management and Sustainable Building Sciences programs at Rock Valley College in Rockford, Illinois. His tenure track at the college started in 2009 and prior to, served as an adjunct member of the faculty since 2002. During that time he held the position of Facilities Planning Manager for the college. Additional experience includes project manager for a regional commercial contractor, vice-president of a local residential building and remodeling company, and a member of Carpenters local 792.

Dan graduated from Southern Illinois University in Carbondale earning a Bachelor of Science degree in Industrial Technology with an emphasis in Plant Layout and Design. He also holds an Associates of Applied Science in Building Construction Technology from Rock Valley College; how he started in teaching. In January of 2011 he enrolled in the Master's program at North Dakota State University to earn a Master of Science degree in Construction Management and Engineering.

Dan has a wife of 16years, Laura, and a nine-year-old son Paul who have supported him through this endeavor.

Permanent address: 10392 William Trail
Roscoe, Illinois 61073
United States of America

This paper was typed by the author.