AN ONLINE CASE STUDY RESOURCE
FOR BUILDING INFORMATION MODELING
IN COLLEGE EDUCATION

An Interactive Qualifying Project Report
submitted to the Faculty of
WORCESTER POLYTECHNIC INSTITUTE
in partial fulfillment of the requirements for the
Degree of Bachelor of Science

Submitted by:
Eric J. Morse

Submitted to:
Prof. Guillermo Salazar, Project Advisor

Date: September 1, 2009
Abstract

The projects objective was to determine how the Academic Group of the AGC-BIMForum can have an impact in promoting and facilitating the adoption of Building Information Modeling (BIM) related concepts in college curriculum by collecting and disseminating educational material through a website. This objective was met through the creation and subsequent analysis of an experimental website designed to disseminate BIM-related case studies. A qualitative web analysis and web metrics were employed to provide future recommendations for improving the experimental website.
Acknowledgements

First and foremost I would like to thank my advisor Guillermo F. Salazar for making this project available and allowing me to become part of the Academic Group of the BIMForum. The resources gained from the May 2009 BIMForum meeting at Las Colinas, TX proved to be invaluable in the completion of this project.

I would like to thank all of the members of the BIMForum and The Associated General Contractors of America (AGC) who made the Spring 2009 meeting possible. A special thanks to John Tocci and Laura Handler of Tocci Building Company, Michael Kenig of Holder Construction Company, and Dimitri Alferieff of the AGC, I appreciate all of your help.

I would also like to thank the members of the BIMForum Academic Sub-forum who took the time to answer the survey and those who participated in our advisory group. All of your thoughts and suggestions were greatly appreciated.
Table of Contents

ABSTRACT ................................................................................................................................................................. I

ACKNOWLEDGEMENTS ...............................................................................................................................................II

TABLE OF CONTENTS ............................................................................................................................................... III

LIST OF TABLES ....................................................................................................................................................... V

LIST OF FIGURES ..................................................................................................................................................... VI

EXECUTIVE SUMMARY ........................................................................................................................................ VII

CHAPTER 1 – INTRODUCTION .................................................................................................................................. 1

CHAPTER 2 – BACKGROUND .................................................................................................................................... 3

2.1 BUILDING INFORMATION MODELING ............................................................................................................... 3

2.2 BIM CURRICULA IN COLLEGES AND UNIVERSITIES ...................................................................................... 3

2.2.1 ONLINE EDUCATIONAL MATERIAL ............................................................................................................. 7

2.2.2 CASE METHOD AS A TEACHING AIDE ......................................................................................................... 8

2.3 BIMForum ................................................................................................................................................ 10

2.3.1 ACADEMIC SUB-FORUM ........................................................................................................................... 10

CHAPTER 3 – METHODOLOGY ............................................................................................................................ 12

3.1 DALLAS BIMForum CONFERENCE .................................................................................................................. 12

3.2 EXPERIMENTAL WEBSITE .......................................................................................................................... 12

3.2.1 WEBSITE PLANNING AND DEVELOPMENT ............................................................................................. 12

3.2.2 WEBSITE ARCHITECTURE ........................................................................................................................ 14

3.3 MEASURING EXPERIMENTAL WEBSITE FUNCTIONALITY ............................................................................ 18

3.4 WEB ANALYTICS ........................................................................................................................................ 18

3.4.1 CONDUCTING A QUALITATIVE WEB ANALYSIS ...................................................................................... 20

3.5 SUMMARY ................................................................................................................................................... 20

CHAPTER 4 – RESULTS AND ANALYSIS ......................................................................................................... 21

4.1 EXPERIMENTAL WEBSITE SURVEY ANALYSIS ............................................................................................ 21

4.2 EXPERIMENTAL WEBSITE ANALYTICAL DATA .......................................................................................... 27

4.2.1 GEOGRAPHIC INFORMATION OF EXPERIMENTAL WEBSITE VISITORS ..................................................... 27

4.2.2 TOTAL UNIQUE PAGE VIEWS .................................................................................................................... 29

4.2.3 TOP EXISTING PAGE .................................................................................................................................. 30
CHAPTER 5 – CONCLUSIONS AND RECOMMENDATIONS ................................................................. 31

5.1 EXPERIMENTAL WEBSITE REVIEW .................................................................................. 31
  5.1.1 EFFECTIVENESS OF COURSE CONTENT ................................................................. 32
  5.1.2 EXPERIMENTAL WEBSITE FUTURE RECOMMENDATIONS .............................. 32

REFERENCES ............................................................................................................................. 35

APPENDIX A – GLOSSARY OF TERMS ..................................................................................... 37

APPENDIX B – EXPERIMENTAL WEBSITE SURVEY REQUEST E-MAIL ............................... 38

APPENDIX C – EXPERIMENTAL WEBSITE SURVEY ............................................................. 39

APPENDIX D – EXPERIMENTAL WEBSITE SURVEY ACTUAL RESPONSES ....................... 44

APPENDIX E – EXPERIMENTAL WEBSITE ANALYTICAL DATA .......................................... 46

APPENDIX F – AGC’S RECOMMENDED BIM CASE STUDY CATEGORIES ......................... 49

APPENDIX G – LINKS ................................................................................................................ 52

APPENDIX H – BIMFORUM ACADEMIC SURVEY .............................................................. 53

APPENDIX I – BUILDINGSMART ALLIANCE EDUCATIONAL BASELINE STUDY ................ 56
List of Tables

TABLE 1 - EXPERIMENTAL WEBSITE SURVEY – PART 1: QUESTION 2 ...................................................22
TABLE 2 - EXPERIMENTAL WEBSITE SURVEY – PART 1: QUESTION 3 ...................................................23
TABLE 3 - EXPERIMENTAL WEBSITE SURVEY – PART 1: QUESTION 4 ...................................................23
TABLE 4 - EXPERIMENTAL WEBSITE SURVEY – PART 1: QUESTION 5 ...................................................24
TABLE 5 - EXPERIMENTAL WEBSITE SURVEY – PART 2: QUESTION 1 ...................................................25
TABLE 6 - EXPERIMENTAL WEBSITE SURVEY – PART 2: QUESTION 2 ...................................................25
TABLE 7 - EXPERIMENTAL WEBSITE SURVEY – PART 2: QUESTION 4 ...................................................26
TABLE 8 - EXPERIMENTAL WEBSITE SURVEY – PART 2: QUESTION 5 ...................................................27
TABLE 9 - GEOGRAPHIC INFORMATION OF EXPERIMENTAL WEBSITE VISITORS .........................28
TABLE 10 - TOTAL UNIQUE PAGE VIEWS .................................................................................................30
TABLE 11 – TOP FIVE EXIT PAGES ........................................................................................................31
List of Figures

FIGURE 1 – BUILDINGSMART ALLIANCE RESULTS – WHO? .................................................................5
FIGURE 2 – BUILDINGSMART ALLIANCE RESULTS – WHEN? .......................................................6
FIGURE 3 – BUILDINGSMART ALLIANCE RESULTS – WHAT? .....................................................6
FIGURE 4 - BIMFORUM ORGANIZATION .......................................................................................11
FIGURE 5 - BLACKBOARD ACADEMIC SUITE TEST WEBSITE ..................................................13
FIGURE 6 - ORIGINAL BIMFORUM.ORG MAIN WEBPAGE .........................................................15
FIGURE 7 - ACADEMIC SUB-FORUM EXPERIMENTAL WEBSITE MAIN WEBPAGE ..................15
FIGURE 8 - MICROSOFT ACCESS CUSTOM SEARCH ENGINE DATABASE ....................................16
FIGURE 9 - "CLASH DETECTION" SEARCH RESULTS ....................................................................17
FIGURE 10 - BASIC AUTHENTICATION FOR EXPERIMENTAL WEBSITE ...............................18
FIGURE 11 - GEOGRAPHIC INFORMATION OF EXPERIMENTAL WEBSITE VISITORS ............28
Executive Summary

Although Building Information Modeling (BIM) has its roots in the mid 1980s only recently has it risen in popularity within the Architectural, Engineering and Construction (AEC) industries. Due to this significant rise in popularity the AEC industry has created a demand for well trained individuals capable of implementing BIM technology in the work place. In an effort to meet these demands various sources have begun the process of introducing BIM-related resources to help facilitate the adoption of BIM technology. One of the first sources to meet this demand was the BIM Handbook: A guide to Building Information Modeling for Owners, Managers, Engineers, and Contractors, published in 2008 by authors Chuck Eastman, Paul Teicholz, Rafael Sacks, and Kathleen Liston.

The BIM Handbook was intended to introduce Building Information Modeling and the technologies that support it, explain how designing, constructing, and operating buildings with BIM differs from pursuing the same activities in the traditional way, and present a rich set of BIM case studies to its readers (Eastman, 2008). Although the BIM Handbook remains a valuable source of information for those in the AEC industry, it still left a void in the market. This void, created by those within academia interested in adding BIM concepts to their curriculum, required additional, more specialized information to meet the specific goal of teaching BIM. To fill this void several organizations were formed with the intent of providing college and university professors the tools they needed to successfully implement BIM-related concepts in the classroom.

In 2007 one of these groups, the Academic Sub-forum of the BIMForum organization, was formed with the intent of determining the current & future industry needs in order to identify and facilitate the implementation of ways to best meet those industry needs. The Academic Sub-forum’s goals were achieved by fostering discussions between various colleges and universities who either currently offered BIM related curriculum or those interested in introducing BIM related coursework to their curricula. By determining the current needs of the industry, as well as the current state of BIM within academia, the Academic Sub-forum was then able to begin supporting academic research and develop BIM curriculum (Salazar, 2008).
Upon determining the current & future needs of the AEC industry it was decided that the best way for the Academic Sub-forum to meet these needs was to begin the planning and development of a comprehensive online resource designed with the purpose of disseminating BIM related course material. After several attempts at developing a comprehensive online educational resource it was decided at the Las Colinas, TX AGC-BIMForum conference in 2009 that this resource should concentrate on the development and implementation of Case Studies rather than providing a comprehensive source of BIM-related material. This report focuses on the planning, development, and subsequent analysis of an experimental online resource dedicated to the dissemination of case study based educational material to college and university professors interested in adding BIM-related content to their curriculum.

The planning of the website first began by determining what the best approach would be to develop such a website. There were several available options which included:

1. **Improving the previous experimental website created by Professor Guillermo F. Salazar of WPI.**
   - http://users.wpi.edu/~salazar/BIMForumAcademic/
2. **Attempt to modify an existing website created by John Tocci, Jr. for the Academic Sub-forum.**
   - http://bimforum.pbworks.com/
3. **Create a new experimental website using a program known as Blackboard.**
4. **Create a new experimental website from scratch using basic HTML code.**

It was decided early on that the best option would be to create a new experimental website rather than build upon an existing platform because the scope of the Academic Sub-forum’s goal had changed from creating a comprehensive BIM resource to concentrating on providing Case Study based educational material. Due to this change in scope, Options 1 & 2 were quickly dismissed. Option 3 was to create a website using a solution known as my.wpi.edu which is powered by Blackboard. This solution is typically used by college and university professors as a tool for organizing and disseminating course content through the internet. Although Blackboard remains a viable tool for educators, after initial testing it was decided that the functionality envisioned for the Academic Sub-forum’s experimental website was not possible with Blackboard. The final option, Option 4, was to create a new experimental website using basic HTML coding. By using HTML the most functionality and ease of development was provided, therefore it was decided that a new experimental website would be created using Option 4.
Due to the fact that the Academic Sub-forum is a part of the BIMForum organization the ultimate goal was to create an experimental website with the capability of being integrated with the BIMForum.org website. In order to facilitate this integration the original layout of the BIMForum website was preserved when creating the Academic Sub-forum’s website (see Figures 6 & 7). The only changes made to the original BIMForum layout was the removal of the original Calendar of Events and BIM News columns. This allowed the creation of the Academic Sub-forum’s navigation menu. By following this approach an environment was created that simulated the experience of working within the BIMForum website while actually operating under a different domain. This was key to the development of the experimental website as it allowed for ease of website maintenance while still lending itself to future integration with the BIMForum’s website.

Once the website’s architecture was set, it was necessary to be determined how the websites content would be organized. Due to the decision to use the case method to provide a context in which learners can practice BIM skills or explore management principles the Academic Sub-forum looked to the AEC industry for anyone currently offering a system of classifying BIM related case studies. The Associated General Contractors of America (AGC) had recently devised a model for organizing case studies (see Appendix F) and as such this method was utilized in the creation of the experimental website.

As soon as the case study filing system was implemented it then became important to devise a system of indexing the available case studies. This goal was accomplished by modifying an open source database driven search engine that utilized a Microsoft Access database to create a catalog of indexed case studies. Not only did this search engine allow for a system of indexing case studies it also allowed the websites users to search available material. When a query is entered into the search engine, found on the “Search Case Studies” page, the access data base is scanned for predetermined keywords. If the query was found within the database an itemized list of case studies is returned with a brief description of the case as well as a direct download link.

Now that the experimental websites development was complete it was necessary for the advisory group to test its performance and functionality. The testing of the new site was done using two primary methods of data collection; these methods included documenting the opinions of those
associated with the advisory group through the use of a brief survey, and by conducting a qualitative web analysis.

The advisory group consisted of 35 individuals with various backgrounds including but not limited to consulting, engineering, architecture, and professional education, were encouraged to participate in a brief survey regarding the performance of the website. The survey was designed with the intent of collecting the most pertinent information while having an estimated completion time of fewer than ten minutes; this was accomplished by breaking the survey into two parts which measured the general teaching practices of the advisory group and the actual functionality of the Academic Sub-forum’s experimental website (see Appendix C).

Although a mere 9% completion rate was recorded with the experimental website survey, some valuable data was collected. The survey suggests that the new Academic Sub-forum website is a step in the right direction. Of the responses collected, 100% of the participants believed that having a website dedicated to promoting and facilitating the adoption of BIM-related concepts in college curriculum was a very useful idea. Additional feedback suggested that although the site was a step in the right direction there was much room for improvement. Most notably, the need to provide educators with a teaching note associated with the case studies available on the website. Also, the need to continue development of the website and add more case studies to the library is paramount in creating a truly viable online educational resource.

In addition to the survey a qualitative web analysis was also conducted by collecting data through web metrics. Google Analytics were employed to measure the experience of the advisory group’s visits by tracking various information including geographic information of websites users, total unique page views, and top exiting pages. Together, this information provided some interesting insight as to the quality of the experimental website.

Geographic information was collected in order to gain a clear understanding of where and by whom the websites material was being used. Due to the fact that all regions of the continental United States were represented in the survey it was decided that it may be helpful to break case studies down into geographic location so users could get relevant information from their perspective locations.
Total unique page views proved to be a very useful piece of information because it provides significant insight as to the viewing habits of the websites users. From this information it was possible to determine that the average user only viewed five web pages per visit. Due to the experimental website having 20 pages with an infinite amount of search possibilities it is important to note that the typical user is only seeing a quarter of what the Academic Sub-forum has to offer. The “bounce rate”, which measures the percentage of users who navigate away from the site via the main page, was also relatively high at nearly 30%. This means that of the 28 users who participated in the experimental website testing, 8 navigated away from the site without exploring what the Academic Sub-forum had to offer.

Finally, the top exiting page was determined to be the websites main page with an exit rate of nearly 39%. This appears to reinforce the fact that too many users were moving away from the website without exploring the information available to them. Based on the information gather from the advisory group as well as the web metrics several recommendations were compiled to help improve the experimental website.

The following measures should be taken to further improve the popularity and usability of the Academic Sub-forum’s experimental website:

- Determine the legality of the Academic Sub-forum’s experimental website.
- Provide teaching notes for all case studies indexed on the experimental website.
- Determine the feasibility of implementing an indexing standard for future case study submissions.
- Breakup undergraduate and graduate coursework into different sections on the website.
  Devise system for classifying undergraduate and graduate coursework.
- Determine how effective the AGC’s method of organizing case studies will work outside of the construction industry.
- Determine feasibility of organizing case studies by geographic location.
- Determine why users are leaving the experimental website without viewing all of its content. Address potential need to increase visual appeal of the websites template.
- Determine the feasibility of moving the experimental website to the BIMForum.org site for a more permanent solution.
- Develop a method of tracking downloads from the experimental website.

It is with hope that these recommendations will help the Academic Sub-forum to significantly improve the usefulness of the experimental website in an effort to make it a truly viable source for college and university professor across the globe.
Chapter 1 – Introduction

In 1986 Graphisoft introduced their first “Virtual Building Solution” known as ArchiCAD (Kmethy, 2008). This revolutionary new software allowed architects to create a virtual, three dimensional (3D) representation of their project instead of the standard two dimensional (2D) objects found in competing computer aided design (CAD) programs of the time. This was important because architects and engineers were then able to store large amounts of data sets “within” the building model (the model). These data sets include the building geometry and spatial data as well as the properties and quantities of the components used in the design. In comparison, designers using standard CAD applications required countless specification sheets in order to convey all of the required information pertaining to the project. The creation of a digitally constructed virtual building model, along with its associated data, is known as Building Information Modeling.

Building Information Modeling (BIM) can be defined as the creation and use of coordinated, consistent, computable information about a building project in design—parametric information used for design decision making, production of high-quality construction documents, prediction of building performance, cost estimating, and construction planning. (Krygiel, 2008). Since the BIM software architecture is based on parametric modeling the geometric consistency and integrity of the building model is maintained in spite of any changes or modifications that may have been made to it. Understanding the concept of these parametric objects is key to understanding what a building information model is and how it differs from traditional 2D design. A parametric object consists of a series of geometric definitions and their associated data and rules. In addition, these geometric definitions are integrated non-redundantly and do not allow for inconsistencies between the model and its associated data set (Eastman, 2008). This means that any changes made directly to the model will result in an equal change to the data set associated with the model.

The precise geometry and relevant data stored within the parametric model provides the details necessary to support the construction, fabrication, and procurement activities needed to realize a building (Eastman, 2008). What this means is that at any point in the projects lifecycle, be it
early conceptual design, construction administration, or even facilities management, the designer has the ability to reference very specific data sets that are stored “within” the model. This relationship between the model and the data associated with the objects within the model are what make BIM technology so powerful.

Although BIM technology is still relatively new, initial experiences indicate that the creation of a 3D model with associated information reduces errors of design, improves design quality, shortens construction time, and significantly reduces construction costs (Eastman, 2003). Due to these initial findings the popularity of BIM has grown tremendously in the past decade, and as the popularity of BIM increases so too has the demand for well trained designers and construction managers with proficiency in the use of BIM technology. Colleges and universities have attempted to meet this demand for well trained individuals by integrating BIM-related content into existing curricula or by developing new curriculum. This has posed a problem for college and university educators as no standardized curriculum or standardized BIM coursework has been made available to them.

In order to begin the process of determining the best solution to providing college and university professors with BIM-related course material it is important to first understand what the current state of BIM is within academia. In addition, there is also a need to understand how the existing material is currently being presented, and how effective this existing material is. Only once these requirements have been met is it possible to begin the process of defining what BIM-based education means, what the basic elements for BIM curricula are, and how to develop new and more effective curriculum.

In an effort to determine the aforementioned requirements the Academic Sub-forum of the BIMForum.org has taken it upon themselves to foster discussion between colleges and universities both nationally and internationally to identify the essential concepts and elements for the development and implementation of BIM-based curriculum, as well as bringing these elements into existing college programs. In addition to reaching out to colleges and universities the Academic Sub-forum actively collaborates with organizations such as the buildingSMART alliance which operates within the independent nonprofit National Institute of Building Sciences, as well as interact with professionals and firms who are currently actively involved in the
implementation of BIM in the design and construction practice. This report focuses on the continuation and implementation of previous research performed by the Academic Sub-forum.

The ultimate goal of the project was to analyze the current state of Building Information Modeling curriculum that has been made available to college and university educators through the use of internet resources. In addition to evaluating the current state of the material available it was also necessary to determine how the dissemination of this material could be improved. These goals were accomplished by collecting data from numerous internet sources offering BIM related curriculum, interviewing individuals within academia who are currently implementing BIM related curriculum, and by tapping into the knowledge of the members within the BIMForum. Together, these sources provided a solid foundation for the development of BIM related course material, as well as the implementation of an experimental website designed to promote and facilitate the adoption of BIM related concepts in college curriculum.

Chapter 2 – Background

2.1 Building Information Modeling

The ability to digitally construct an accurate virtual model of a building has made Building Information Modeling (BIM) technology one of the most promising developments in the architecture, engineering and construction (AEC) industries (Eastman, 2008). As the popularity of using 3D modeling software rises within the AEC industry so too does the demand within academia to produce well trained individuals capable of implementing BIM technology immediately upon entering the work force. Due to these demands more and more colleges and universities have begun the process of developing and integrating BIM-related course content into their curricula.

2.2 BIM Curricula in Colleges and Universities

Until recently there was very limited information available to college and university professors interested in introducing BIM-related course content to their students. This began to change in 2008 when authors Charles Eastman, Paul Teicholz, Rafael Sacks, and Kathleen Liston
published the BIM Handbook: A Guide to Building Information Modeling for Owners, Managers, Designers, Engineers and Contractors. The BIM Handbook was intended to introduce Building Information Modeling and the technologies that support it, explain how designing, constructing, and operating buildings with BIM differs from pursuing the same activities in the traditional way, and present a rich set of BIM case studies to its readers. The trend in publishing BIM related material has continued into 2009 with some more recent notable publications including Dana K. Smith and Michael Tardif’s book, Building Information Modeling: A Strategic Implementation Guide for Architects, Engineers, Constructors, and Real Estate Asset Managers, published in April of 2009. Additional sources include Brad Hardin’s book, BIM and Construction Management: Proven Tools, Methods, and Workflows, published in May of 2009.

Although these publications provide invaluable information to those interested in adding BIM-related content to their curriculum there were still relatively few viable online resources geared specifically to meeting the demands of college and university educators. In order to solve this problem the Academic Sub-forum of BIMforum.org had begun the process of planning and developing such an online resource as far back as 2007 when they assembled an online survey developed to measure the current state of BIM within academia.

The survey, last updated on July 17, 2007, collected responses from eight academic institutions within the United States and three abroad. The survey collected data on the following subjects (See Appendix H for the 2007 BIMForum Academic Survey):

- Is BIM formally taught or discussed in courses or projects?
- At what level is BIM formally taught or discussed in courses or projects?
- When did you start introducing BIM into your program?
- How Extensive is the BIM related activity in your academic program?
- How fast is BIM growing in your academic program?
- Where are you heading in the short/long term?
- What kind of software do you use?
- How supportive is the software industry of your needs?
- Does industry support your activities?
- Are you or your students and/or other faculty involved in research in this area?
According to the participants of the Academic Sub-forum’s July 2007 survey more than 82% of the academic institutions were formally offering BIM-related coursework. Approximately 55% of those institutions only began offering BIM-related curriculum within the past 2 years.

In addition to the research performed by the Academic Sub-forum, the buildingSMART alliance conducted an Education Baseline Study in 2008. The purpose of this study was to first establish a baseline for metrics from which they could then measure progress in the future. Once this baseline was formed a comprehensive survey was conducted to gather information pertaining to who, what, when, and how college and university professors were implementing BIM related curriculum.

The original study by the buildingSMART alliance, available in Appendix I, was based on the responses to an online survey that were given by 93 individuals from three different countries, representing a total of 68 unique schools and universities. The vast majority of these responses were from faculty members; however several researchers, administrator, and physical plant personnel also participated in the survey (see Figure 1).

**Figure 1 – buildingSMART alliance results – WHO?**

Additionally, the survey asked participants to document when existing programs were established. As with the Academic Sub-forum survey, the participants of the buildingSMART alliance baseline study showed that the many of the programs were established within 2 years of the survey. Interestingly, only 7% of the participants were using BIM prior to 2004. Only then
did the implementation of BIM in the classroom begin to become more popular. See Figure 2 for more information.

Figure 2 – buildingSMART alliance results – WHEN?

![Figure 2](image)

Finally, the survey was used to compile information regarding which BIM related concepts were currently being implemented within academia. The participants were questioned on several categories including Sustainability, Visualization, Phasing & Scheduling, Database (I/M), Industry Foundation Classes (IFCs) & Interoperability, Analysis, Construction, and finally Safety. The results indicate that Visualization, Phasing & Scheduling, and Construction were the most popular while Sustainability, Analysis, and Database (I/M) rounded out the top six areas where BIM was being used in the classroom (see Figure 3).

Figure 3 – buildingSMART alliance results – WHAT?

![Figure 3](image)
2.2.1 Online Educational Material

Due to the amount of online educational material continually being made available and in such an uncoordinated fashion, the importance of creating an online resource has become more important than ever. But before these resources can be organized effectively it is important to understand what material is currently being made available, and by who. Today, there are currently several key players in the dissemination of online educational material for BIM related courses. Many of these sources are offering BIM related coursework in the form of case studies and although there are additional sources that offer coursework in alternative forms, most notably the increasing amounts of publications of BIM related material, they will not be discussed here.

The key players that are of concern for this project may be broken down into three groups; these groups include:

- College and University programs
- Professional Organizations
- Software Developers

Several college and university programs currently offer BIM related course content. The most significant contribution to academia within this group has been made by Georgia Tech. The BIM Resources website developed by Georgia Tech contains numerous references for college and university professors including case studies, technical reports, journals & conference papers, a list of related sites, and a series if BIM tools for various software packages, as well as several tutorials for parametric modeling within these software packages. Additional content has been made available by various colleges and universities including but not limited to Worcester Polytechnic Institute, the Yale School of Architecture, and Wentworth Institute of Technology.

There is also a wealth of information available to educators from a variety of professional organizations, although the material is not always formatted for use in the classroom. Organizations including but not limited to the Associated General Contractors of America (AGC), the buildingSMART alliance, and the Whole Building Design Guide provide case studies on their websites.
Finally, many of the software developers currently offering BIM solutions are also offering case study based coursework for use by college and university professors. Autodesk, Bentley Systems, and ArchiCAD all offer case studies geared towards college curriculum for download on their websites. In addition to offering college curriculum online, Bentley Systems, Autodesk, and ArchiCAD all have versions of their software available to students and faculty free of charge. Unfortunately, due to the nature of this material, its usefulness is based on the availability of the software package to the educator and as such they have not been added to the case study database.

For more information on these key players please refer to Appendix G for links to their representative websites.

2.2.2 Case Method as a Teaching Aide

Why Use the Case Method?

The case method is a powerful learning model which utilizes a set of techniques along with real world experience to help students reach very specific learning objectives. With the use of case studies students are introduced to a simulated decision-making exercise based on real situations experienced in the industry, working under stringent time constraints, and often with incomplete data sets. This requires the student to challenge their capabilities while preparing them for future managerial decision making. In short, the case study is designed to further the development of professional intellectual and behavioral skills through the use of problem-oriented studies based on real world experiences. This method of teaching was introduced by Harvard Law School as early as 1870 and remains such a powerful tool that countless colleges and universities have integrated the case method into their curricula.

The Case Study Format

In order to take full advantage of the case method in the classroom a standardized form should be followed when writing a case. There are several different case study models that may be followed but a conventional approach should be used when preparing a case. An effective case study outline should include all of the following information (Lynn, 1999):
• **Title**
  - An introductory paragraph should be used to familiarize the reader of the issues that will be solved through the research presented in the case study.

• **Introduction** – The background should include both general and specific information relating to the case. What events led to the creation of the case study?

• **Background** – The opening statement is the beginning of the narrative.

• **Opening Statement** – The opening statement is the beginning of the narrative.

• **Key Incidents** – Include the key incidents which led to the initiation of action. What problems were encountered?

• **Additional Events** – Inform the reader of any additional events that pertain to the problem being analyzed.

• **Decision** – The most important aspect of the case study; how were issues encountered during research solved? What important lessons have been learned from the research presented in the case?

• **Closing Statement** – “Where are we now?” What work has been done, and what still needs to be addressed? The closing statement should set the stage for future research.

• **Appendices** – Include any additional information needed for analysis, as required.

Additionally, the case should also be accompanied by a separate section dedicated to teaching notes. The purpose of the note is to give other potential instructors valuable insights into the case and the learning which can be derived from it. It should also provide suggestions on how to maximize the learning potential of the case. In order to accomplish this, the following outline should be emulated when creating a teaching note (McCracken, 2009):

• **Summary of the case** – The teaching note should include a brief description of the case and its context.

• **Teaching objectives and target audience** – It should describe, with examples, the key issues and intended learning objectives, indicating the target group or class level for which the case was written.

• **Teaching approach and strategy** – It should suggest how the case may be used in class and ways in which the class may be conducted. It may offer ‘trigger’ questions for opening and advancing the case discussion, suggestions for group work or student assignments, how to consolidate the learning, etc. Useful additional information could include suggestions for a teaching plan. It should also give some indication of the case’s demands on course time-tabling.

• **Analysis** – The analysis should offer comprehensive answers to the list of questions and should, at least, be as thorough as one would expect from the best student. If the case includes quantitative data, it might suggest ways of utilizing the data, and should ideally include the details of any spreadsheet analysis. At the very least it should indicate the techniques to be used for analyzing the data.
Additional readings or references – Suggested additional readings should be listed if it is necessary (or helpful) for students to read text or other material in conjunction with the case. Specific readings can be assigned from these lists.

Feedback - It should provide an indication of how the case worked with different student groups; where possible indicating the case’s suitability for written assessment or examination, role-playing, or other forms of use. Where known, it might also include the actual outcome of the case situation, and some follow-up facts.

2.3 BIMForum

The BIMForum’s mission is to facilitate and accelerate the adoption of BIM in the Architectural, Engineering, and Construction (AEC) industry. This mission is to be accomplished by synchronizing with counterparts in all sectors of the industry to jointly develop best practice for virtual design and construction (VDC), with the ultimate goal of revolutionizing the building industry (BIMForum.org, 2009).

Although the BIMForum organization operates as a unified group chaired by John Tocci of Tocci Building Corporation, there are six sub-forums that represent the major relevant industry sectors. The sub-forums operate with each other and other industry organization on interdisciplinary projects to accelerate the adoption of BIM (BIMForum.org, 2009). These sub-forums include The Designers’ Sub-forum, the Builders’ Sub-forum, The Legal Sub-forum, The Software Sub-forum, The Users Sub-forum, and finally The Academic Sub-forum (see Figure 4). Although all Sub-forums play a pivotal role in the adoption of BIM the Academic Sub-forum is of key importance to the adoption and implementation of BIM within academia. For more information regarding the specific functions of the aforementioned sub-forums please see Appendix G for a direct link to the BIMForum website.

2.3.1 Academic Sub-forum

The Academic Sub-forum, currently chaired by Professor Guillermo F. Salazar of Worcester Polytechnic Institute, was assembled in January of 2007 at the Captive Island, FL BIMForum conference. The group was formed with the intent of determining the current & future industry needs in order to identify and facilitate the implementation of ways to best meet those industry needs. The Academic Sub-forum’s goals were achieved by fostering discussions between various colleges and universities who either currently offered BIM related curriculum or those that are
interested in introducing BIM related coursework to their curricula. By determining the current needs of the industry, as well as the current state of BIM within academia, the Academic Sub-forum was then able to support academic research and develop BIM curriculum (Salazar, 2008).

Today, the Academic Sub-forum has continued facilitating the adoption of BIM-based curriculum by identifying the essential concepts and elements for the development or implementation of BIM-based curriculum. One concept identified through discussions at BIMForum conferences is the need for an online education resource with the purpose of disseminating BIM related course material. After several attempts at developing a comprehensive online education resource it was decided that the resource should concentrate on the development and implementation of Case Studies. The following chapter details the methodology behind the development and implementation of the Academic Sub-forum’s new experimental website designed to disseminate BIM-related course material created using the case method.

Figure 4 - BIMForum Organization

< http://www.bimforum.org/index.php?option=com_content&task=view&id=17&Itemid=31>
Chapter 3 – Methodology

3.1 Dallas BIMForum Conference

The AGC BIMForum conference held on May 28 -29 in Dallas Texas brought together over 300 architects, contractors, engineers, and software developers. The theme for the presentations was “The 30 day to 30 year Perspective” and focused on both the short and long term goals of BIM within the AEC industry. The presentations included topics such as BIM ROI from an Owner’s perspective, Conceptual Estimating, Implementing BIM in Your Firm, Horizontal BIM, a Rapid Fire Technology Demonstration, and a number of breakout sessions for the various BIMForum Sub-forums (BIMForum.org, 2009).

The Academic Sub-forum hosted a total of nine individuals representing five unique academic institutions, Graphisoft Virtual Building Solutions, and the buildingSMART alliance. The session concentrated on the planning, development, and implementation of case studies in an online education resources website.

3.2 Experimental Website

The Academic Sub-forum’s breakout session at the BIMForum conference on May 29th provided the opportunity to gather preliminary information regarding the feasibility of creating a website dedicated to supplying college and university professors with the educational material required to integrate BIM-related coursework into their curricula. It was decided, overwhelmingly so, that an online resource which provided case study based education material would remain a valuable resource to educators.

3.2.1 Website Planning and Development

After initial interest was established the preliminary planning of the website began. One of the biggest decisions that needed to be made at this time was how the development of the site would progress. There were several options available to us which included:

1. Improving the previous experimental website created by Professor Guillermo F. Salazar of WPI.
   ○ http://users.wpi.edu/~salazar/BIMForumAcademic/
2. Attempt to modify an existing website created by John Tocci, Jr. for the Academic Sub-forum.
3. Create a new experimental website using a program known as Blackboard.
4. Create a new experimental website from scratch using basic HTML code.

It was decided fairly early on that the best option would be to create a new experimental website rather than build upon an existing platform. This decision was made due primarily to ease of development and operability of the site but also because of time constraints on the project. Attempting to modify an existing website would require obtaining special permissions to access the host, or worse, relying on outside sources to update the site periodically; because of this, options 1 & 2 were quickly dismissed. Option 3 was to create a website using a solution known as my.wpi.edu which is powered by Blackboard. This solution is typically used by college and university professors as a tool for organizing and disseminating course content through the internet. Although Blackboard remains a viable tool for educators, after initial testing it was decided that the functionality envisioned for the Academic Sub-forum’s experimental website was not possible with Blackboard. The final option, Option 4, was to create a new experimental website using basic HTML coding.

Figure 5 - Blackboard Academic Suite Test Website
By using HTML coding the most functionality and ease of development was provided. An additional requirement for the experimental website is that it would need to function independently of the BIMForum website during its developmental stages, while still lending itself to a seamless integration to the BIMForum website in the future. Although my.wpi.edu meets the criteria of operating independently of the BIMForum website, it does not lend itself to seamless integration with the existing BIMForum.org website. Therefore, it was decided that a new experimental website would be created using basic HTML coding.

3.2.2 Website Architecture

One of the most important design aspects of the Academic Sub-forum experimental website was maintaining interoperability. The experimental website needed to operate independently from the BIMForum.org website in order to facilitate development, but at the same time the experimental website needed to work along with the BIMForum.org site to create a truly viable resource for college and university professors. This interoperability was accomplished by preserving the original BIMForum.org website template and making a series of modifications to its layout in an effort to enhance its functionality for the Academic Sub-forum website.

Layout & Navigation

Several key changes were made to the original BIMForum website layout in an effort to enhance functionality of the Academic Sub-forum website. Most notably, the BIM News, Calendar of Events, and BIMForum search engine were removed from the column on the left hand side of the page (see Figure 6). By removing the BIM News & Calendar of Events, and relocating the BIMForum search engine, it was then possible to create a menu on the left hand side of the page for navigating the experimental website (see Figure 7).

This was a very important design element because not only does this “sub” menu allow the user to traverse the new Academic Sub-forum website, but it also allows them to maintain all of the same functionality of the original BIMForum.org website by preserving the main navigation menu found below the BIMFORUM logo at the top of the screen. What this does is create a truly integrated design that allows the websites to function independently from each other while still maintaining interoperability.
Figure 6 - Original BIMForum.org Main Webpage

Figure 7 - Academic Sub-forum Experimental Website Main Webpage
Custom Search Engine

A database driven search engine was implemented by modifying an open source Active Server Page (ASP) search engine code written by Faisal Kahn, chief author of stardeveloper.com (Kahn, 2000). The search engine utilizes a Microsoft Access database as the primary means of indexing case studies.

Figure 8 - Microsoft Access Custom Search Engine Database

In order to perform a search of available case studies the user must first navigate to the “Search Case Studies” page by using the aforementioned navigation menu. After a query is created by entering a keyword into the search box the website sorts through a list of predetermined case studies indexed using a Microsoft Access database (see Figure 8). If the search yields no results the user is automatically redirected back to the search page after five seconds where they are given the option of performing a new search. In the event that a keyword is found within the database an itemized list of results is reported to the user.

A simple search was performed using the keywords “clash detection”. The user is given a summary of the search results at the top of the page which includes the page number, the number of case studies found meeting the search criteria, and a reminder of the search keywords entered. Immediately following this summery an itemized list of case studies is presented. A direct link to the case study is given in orange, followed by a brief description of the case study and the full URL of the case study with the date it was indexed.
The report generated by this search may be found in Figure 9. This experimental search engine serves only as a model of the functionality required by the Academic Sub-forum and does not represent a final product in any way.

Figure 9 - "Clash Detection" Search Results

Security

An additional challenge encountered when creating a website for disseminating BIM-related course content to college and university professors was receiving permission for the use of said material on the experimental site. This hurdle was overcome by implementing a basic authentication process through which only individuals associated with the advisory group for BIMForum Academic Sub-forum would have the credentials to gain access. As soon as the user attempted to view the experimental website an authentication box appeared, once this initial authentication was met, the user had free access to the entire site. The goal is to eventually remove this authentication once permission to use all of the course material has been granted to the Academic Sub-forum. See Figure 10 for an example of the authentication process.
3.3 Measuring Experimental Website Functionality

Once the experimental website was developed it was then time to test its functionality. This was done primarily through the use of an advisory group consisting of 35 individuals with various backgrounds including but not limited to consulting, engineering, architecture, and professional education. Upon thorough review of the experimental website, the members of the advisory group were encouraged to participate in a brief survey regarding the performance of the website. The survey was designed with the intent of collecting the most pertinent information while having an estimated completion time of fewer than ten minutes; this was accomplished by breaking the survey into two parts.

Part 1 of the survey covered general information regarding the teaching practices of the advisory group while Part 2 covered the functionality of the Academic Sub-forum experimental website. Due to the limited size of the advisory group numerous open ended questions were used throughout the two part survey. This approach allowed for the most efficient collection of data by allowing the user to express his/her opinions in their own words rather answering a series of multiple choice questions.

3.4 Web Analytics

Web analytics, often called web metrics, provide the tools for the measurement, collection, analysis, and reporting of internet data for the purpose of understanding and optimizing web usage (Web Analytics Association, 2009). These tools may be broken down into two categories,
namely offsite tools and onsite tools. Offsite tools are used to measure the size of your potential audience (opportunity), your share of voice (visibility), and the buzz (comments) that is happening on the internet as a whole (Clifton, 2008). These are relevant metrics regardless of your website’s existence. Onsite tools on the other hand measure the visitor’s journey, its drivers, and the website’s performance. These are directly related to your websites existence (Clifton, 2008).

Jason Burdy and Shane Atchinson, coauthors of Actionable Web Analytics, define four important steps that can help users achieve successful web analytics. These steps include (as cited in Connelly, 2008):

1. Determine Key Performance Indicators (KPIs)
2. Create Reports
3. Conduct an Analysis
4. Optimize and take action

In order to successfully utilize web analytics and benchmark the success of the experimental website it was important to first determine several key performance indicators (KPIs). KPIs provide a distillation of a plethora of website visitor data available as clear, actionable information (Clifton, 2008). In short, KPIs represent a series of key factors which measure the success of the website, or lack thereof. The two KPIs chosen for analysis were the geographic location of our users and the number of unique page views of the experimental website.

By defining the two KPIs as the geographic location of the users and the number of unique pages views it was possible to determine how well the responses from the advisory group represented the actual target audience of the experimental website. Additionally, it would be possible to collect information relating to the sites architecture including the top “exit pages” of the site. Determining the top exit page, the page users are most likely to leave the website on, allows for future development suggestions for the website. It also provides some insight as to why users were leaving the experimental website as well as providing the site developer with important information as to how the website needed to be improved.
3.4.1 Conducting a Qualitative Web Analysis

Google Analytics were employed in order to conduct a qualitative web analysis of the experimental website. Google Analytics is the enterprise-class web analytics solution that provides rich insights into the websites traffic and marketing effectiveness (Google Analytics, 2009). By implementing Google Analytics it was possible to not only set a benchmark for the collection of analytical data but was also given the power to create numerous reports relating to the KPIs determined in section 3.4.

3.5 Summary

In an effort to identify the essential concepts and elements for the development or implementation of BIM-based curriculum as well as to bring these elements into existing college programs an experimental website was created using insight from the members of the Academic Sub-forum. The experimental website was designed with the intent of disseminating BIM-related course content to college and university professors interested in either introducing BIM to their curricula or improving existing course curriculum.

Once the experimental website was completed an advisory group was asked to thoroughly review the website and provide feedback through the use of a brief 10 question survey. The survey was designed to maximize feedback by allowing the users to answer several open ended questions with specific recommendations rather than filling in a series of multiple choice questions.

In addition to the survey, web analytics were also utilized to collect information regarding the users experience while on the new site. Multiple reports were generated from the data collected from the analytical data with the most notable being the users’ geographic information as well as the number of unique page views. Additional information including the top exit page, average time on site, and bounce rate were also collected. This data allowed for the evaluation of the experimental website and the development of conclusions and the creation future recommendations.
Chapter 4 – Results and Analysis

After developing the experimental website it was necessary to determine how successful the initial efforts were. This was done primarily through the acquisition of feedback from members of the Academic Sub-forum, and by analyzing data collected from conducting a qualitative web analysis. For a copy of the original survey please see Appendix C.

4.1 Experimental Website Survey Analysis

In an effort to measure the overall success of this project the advisory group was asked to take a few moments to review the experimental website and provide feedback based on their findings through the use of an online survey powered by SurveyMonkey.com. Due to time constraints minimal feedback was collected and as of August 25, 2009 the response rate for the survey was a mere 9%.

The survey was designed to be completed in fewer than 10 minutes and actual response times ranged from 3 to 9 minutes. Although the feedback collected ranged in detail, all questions were successfully answered by the participants. In spite of relatively poor support for the survey the responses collected do offer some insight as to the success of the new experimental website.

For the actual survey responses please see Appendix D.

Survey - Part 1
Question 1 – Demographic Information

The primary purpose of collecting demographic information was to determine who was using the experimental website and where they resided. Representatives from Worcester Polytechnic Institute in Worcester, MA, Ferris State University in Big Rapids, MI, and Northern Arizona University in Flagstaff, AZ participated in the survey. The academic programs represented by these academic institutions included Construction Management and Architectural Technology.
Question 2 – Are you teaching any courses that require BIM related content? (Check all that apply)

Question 2 was designed with the intent of determining who the Academic Sub-forum’s experimental website would most likely attract. If the survey results are any indication of who will be using the website in the future it is possible to make a determination that the majority of the course content should be geared towards individuals currently teaching BIM-related course material. Additionally, results show that the site will be used to collect data for both undergraduate and graduate level course material which is something that was not previously addressed when planning the layout of the experimental website.

Table 1 - Experimental Website Survey – Part 1: Question 2

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning on teaching BIM-related curriculum</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Currently teaching BIM-related curriculum</td>
<td>100.0%</td>
<td>3</td>
</tr>
<tr>
<td>Undergraduate Level</td>
<td>66.7%</td>
<td>2</td>
</tr>
<tr>
<td>Graduate Level</td>
<td>66.7%</td>
<td>2</td>
</tr>
</tbody>
</table>

answered question 3
skipped question 0

Figure 10 – Experimental Website Survey – Part 1: Question 2
Question 3 – Do you use the case method for teaching any of your courses?

The purpose question 3 was to shed light on the existing practices of college and university professors. Additionally, it provided some insight as to how feasible maintaining a website dedicated to the dissemination of course material in the form of case studies would be.

Table 2 - Experimental Website Survey – Part 1: Question 3

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>100.0%</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 3
skipped question 0

Question 4 – Where do you typically find instruction material for your courses? (Check all that apply)

The intent behind asking where educators typically find course material was to gauge which method of gather information is most important to the average educator. By determining where educators are most likely to find their material the Academic Sub-forum could then modify the way information is being disseminated.

Unfortunately, due to the limited number of responses there is not enough data to make a determination as to what source remains the most important to those educators. Additionally, the question could have potentially been revised to ask what source of material remains the most important to the individual, rather than checking all that apply.

Table 3 - Experimental Website Survey – Part 1: Question 4

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colleagues</td>
<td>66.7%</td>
<td>2</td>
</tr>
<tr>
<td>Books</td>
<td>66.7%</td>
<td>2</td>
</tr>
<tr>
<td>Internet</td>
<td>66.7%</td>
<td>2</td>
</tr>
<tr>
<td>Conferences</td>
<td>66.7%</td>
<td>2</td>
</tr>
<tr>
<td>Working Professionals</td>
<td>100.0%</td>
<td>3</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

answered question 3
skipped question 0
Question 5 – Would you be interested in contributing BIM related coursework to the Academic Sub-forum’s website?

Measuring support for the Academic Sub-forum is important when determining the feasibility of maintaining the experimental website. In order to keep the content relevant and up to date it is necessary to continually introduce new case studies into the library. Although relatively few responses were collected, support for the Academic Sub-forum appears to remain high.

Table 4 - Experimental Website Survey – Part 1: Question 5

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>100.0%</td>
<td>3</td>
</tr>
<tr>
<td>No</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

answered question 3
skipped question 0

Survey - Part 2

Question 1 – How useful is the concept of having a website dedicated to the promoting and facilitating the adoption of BIM-related concepts in college curriculum to you?

Question 1 of Part 2 was designed to assure that the Academic Sub-forum was moving in the right direction by developing a website catered to those within academia.

Additionally, users were asked if they were aware of any additional websites that provide a similar service when compared to the Academic Sub-forum’s experimental website. Participants noted the buildingSMART alliance website (http://www.buildingsmartalliance.org/) and the VICO Software website (http://www.vicosoftware.com/) as viable sources for collecting BIM-related course material.
Table 5 - Experimental Website Survey – Part 2: Question 1

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Useful</td>
<td>100.0%</td>
<td>3</td>
</tr>
<tr>
<td>Somewhat Useful</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Neither</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Not very Useful</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Useless</td>
<td>0.0%</td>
<td>0</td>
</tr>
</tbody>
</table>

Are you aware of any other website which provide similar services to this experimental website? If so please list them here: 2

answered question 3
skipped question 0

Question 2 – Overall, How would you rate the experimental website?

Although the experimental website was generally well received there were several notable suggestions that were collected from the survey.

The biggest question that came up was the legality of modifying copyrighted material for educational purposes. This is one aspect that was not addressed within this study.

Additional comments included the need to add more case studies to the existing library in order to make the experimental a viable website.

Table 6 - Experimental Website Survey – Part 2: Question 2

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
<th>Very Poor</th>
<th>N/ A</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Layout</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Visual Appeal</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Ease of Navigation</td>
<td>1</td>
<td>2</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Ability to Find Pertinent</td>
<td>2</td>
<td>1</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Additional Comments</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

answered question 3
skipped question 0
Question 3 – Please provide any additional comments or suggestions that you may have pertaining to the Academic Sub-forum experimental website’s architecture.

One participant suggested that there was a “...need to have this site accessible to non-member faculty”.

As covered in section 3.2.2 Website Architecture it was necessary to restrict access to the site due to possible copyright infringements. Ideally, this web authentication process will not be required once permission has been granted by the case study creator to modify the case for educational purposes. The remaining two participants did not have any additional comments.

Question 4 – Would you like to see the case study format improved?

Although it was agreed that the case study format should be improved there was no definitive answer as to what specific information needed improvement. However, it was suggested that “better narratives associated to the slides” should be provided. This is one area that must be improved with future work. Many of the case studies indexed on the site provide no narrative for the professor what so ever rendering them ineffective at best.

Table 7 - Experimental Website Survey – Part 2: Question 4

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>100.0%</td>
<td>2</td>
</tr>
<tr>
<td>No</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td>3</td>
</tr>
</tbody>
</table>

answered question 2
skipped question 1

Question 5 – How useful are the case studies presented on this site?

Although the case studies provided were useful there is always room for improvement. As in Question 4, better narratives are required in order to get the most out of the case studies in the classroom.
Table 8 - Experimental Website Survey – Part 2: Question 5

<table>
<thead>
<tr>
<th>Answer Options</th>
<th>Response Percent</th>
<th>Response Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Useful</td>
<td>66.7%</td>
<td>2</td>
</tr>
<tr>
<td>Somewhat Useful</td>
<td>33.3%</td>
<td>1</td>
</tr>
<tr>
<td>Neither</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Not very Useful</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Useless</td>
<td>0.0%</td>
<td>0</td>
</tr>
<tr>
<td>Other (please specify)</td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

**answered question** 3  
**skipped question** 0

4.2 Experimental Website Analytical Data

Web analytics were employed in order to get a better idea of the experimental websites performance without collecting feedback directly from the advisory group. The web analytics were used to collected data for the analysis of three areas of focus. Those areas included:

1. Geographic Information of Website Visitors
2. Total Unique Page Views
3. Top Existing Page

4.2.1 Geographic Information of Experimental Website Visitors

It was important to collect the geographic information of the website visitors in order to gain a clear understanding of where and by whom the course material presented on the site was going to be used. By understanding who will be using the site it is possible to cater to the individual users needs. For instance, if the website had been used primarily by college and university educators in the Northeast it may have been beneficial to restrict case studies which were created from projects on the west coast. Conversely, projects on the east coast may not be as practical to educators in the west.

As shown in Figure 10 below, the website attracted users from all five regions within the continental United States. This leads to the question of whether or not case studies should be cataloged by region in addition to the AGC’s recommended format for case studies (See Appendix E for more information on the AGC’s categories).
Figure 11 - Geographic Information of Experimental Website Visitors

Table 9 - Geographic Information of Experimental Website Visitors

<table>
<thead>
<tr>
<th>Region</th>
<th>Visits</th>
<th>Visits</th>
<th>Region</th>
<th>Visits</th>
<th>Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td>17</td>
<td>60.71%</td>
<td>Virginia</td>
<td>3</td>
<td>10.71%</td>
</tr>
<tr>
<td>California</td>
<td>2</td>
<td>7.14%</td>
<td>Texas</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Texas</td>
<td>1</td>
<td>3.57%</td>
<td>Kansas</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Colorado</td>
<td>1</td>
<td>3.57%</td>
<td>Michigan</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Michigan</td>
<td>1</td>
<td>3.57%</td>
<td>Arizona</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>1</td>
<td>3.57%</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
4.2.2 Total Unique Page Views

Total unique pages views are an important statistic because it provides significant insight as to the viewing habits of the websites users. As seen in Table 10, we are able to see that there were 99 unique page views and a total of 134 page views. From this information, combined with the 28 unique visits from Table 9, we are able to determine that the average users looked at only 5 pages per visit. As of August 25, 2009 the Academic Sub-forum’s experimental website had approximately 20 web pages with an infinite number of unique pages derived from search queries. This means that at a minimum the users are only seeing one quarter of what the experimental website has to offer. This relatively low page per visit rate may be explained in several different ways.

Although it is possible the users were able to navigate directly to the course content they are interested in requiring a minimum number of page visits, this is highly unlikely for a test website as the users are unfamiliar with its layout. An additional piece of data collected from the web analytics may explain what the issue is: The bounce rate, as shown in Table 9, is nearly 30%. The bounce rate measures the percentage of users who navigated away from the site via the main page. This means that of the 28 users who participated in the experimental website’s testing 8 users navigated away from the site without exploring what the Academic Sub-forum had to offer.

A possible explanation of why so many users are being sent away from the Academic Sub-forum website may be the way the site was designed. The experimental website was designed with the purpose of operating within the BIMForum.org website. In an effort to simulate this condition, the original navigation menu from the BIMForum website was left intact (see section 3.2.2 Website Architecture for more information). It is possible that the participants were attempting to use this main navigation bar and were being sent away from the Academic Sub-forum site and directly to the BIMForum.org website. This would issue would be remedied after the experimental site had been fully integrated and operating within BIMForum.org.
Additionally, of the twelve categories of case studies available to the users on the experimental website, only half of them had been accessed more than twice. Note that the gray portion of the graph above represents webpage’s with a total number of views less than three. Over 21% of the web pages had been views fewer than three times. Unfortunately, the results do not explain why the additional webpage’s had not been accessed but it may be possible to draw some conclusions. Due to the relatively small advisory group the data collected may not be truly representative of the type of traffic the Academic Sub-forum group will receive in the future. Only further testing on a larger scale will provide insight as to why visitors are being lost.

4.2.3 Top Existing Page

Table 11 below shows the top five exit pages for the Academic Sub-forum experimental website. The data appears to reinforce the idea that the participants were using the main navigation bar at the top of the screen which subsequently redirected them to the BIMForum website.
Chapter 5 – Conclusions and Recommendations

5.1 Experimental Website Review

A meeting was scheduled for the Academic Sub-forum to meet on Tuesday, August 25, 2009 with the primary goal of the meeting to discuss the potential for presenting the new experimental website at the next AGC-BIMForum conference in Philadelphia, PA on October 8 & 9.

Although support for the experimental website has remained strong it was clear from this meeting that significant changes needed to be made in order to make the site a truly viable resource for college and university professors.

Several of the attendees brought up the fact that the Academic BIMForum website will not be used solely by those interested in construction management. As such, using the AGC’s system of organizing case studies may not be the best approach for organizing case studies for those interested in other disciplines such as Architectural Design.

Additionally, the survey conducted on our advisory group indicates that the website will be used by professors teaching BIM at both the graduate and undergraduate level. This had not been taken into account when organizing the existing case study directory.
5.1.1 Effectiveness of Course Content

Although the coursework presented on the site remains an effective teaching aid there is clearly room for improvement. Better narratives or teaching notes as described in the methodology are a must. Since case studies are simply being linked to the Academic Sub-forum there are no terms of use violations with the current setup, however, if teaching notes were to be created from copyrighted material potential issues could arise. This leads to the problem of who will be responsible for creating these teaching notes.

The survey suggests that the users of the Academic Sub-forum website would be interested in contributing coursework to the website. In the future, when these submittals are received by the Academic Sub-forum it would be helpful if an indexing guideline was created to standardize the case studies.

5.1.2 Experimental Website Future Recommendations

1. Case Study Permissions

Determine the legality of the Academic Sub-forum’s experimental website. One of the biggest limitations to this report is the legality of disseminating coursework from various sources over the internet with the intent of modifying it for educational purposes.

2. Case Study Teaching Notes

All case studies should be provided with a teaching note for use by college and university educators when planning their lesson. It is unclear who should be responsible for writing these teaching notes, especially when cataloging various case studies found on the internet. If accepting course material from members of the Academic Sub-forum it may be beneficial to measure the feasibility of requiring a teaching note prior to being published on the site.

3. Indexing Standard

Determine the feasibility of implementing an indexing standard for future case study submissions. If feasible, develop the indexing standard guidelines for the Academic Sub-forum.
4. **Graduate vs. Undergraduate Studies**

There could potentially be a need to breakup undergraduate and graduate coursework into different sections on the website. Devise system for classifying undergraduate and graduate coursework.

5. **Interdisciplinary Filing of Case Studies**

Due to the fact that users interested in multiple disciplines will be using this site it will be necessary to determine how effective the AGC’s method (Appendix E) of organizing case studies will work outside of construction management.

6. **Organizing Case Studies Based on Geographic Location**

Due to the fact that all regions of the continental United States were represented in the survey it was decided that it may be helpful to break case studies down into geographic location so users could get relevant information from their perspective locations.

7. **Exiting Page/ Bounce Rate Issues**

Determine why so many users are leaving the experimental website without viewing its content. This may be because of limitations to the layout as described in Section 4.2.2 Total Unique Page Views or simply a lack of visual appeal.

8. **General Academic Sub-forum Website Issues**

The website was developed with the intention of eventually becoming part of (working under) the BIMForum website. This site would not be hosted separately as was originally done with previous test website. There are several foreseeable issues with the desired configuration:

- How are educators to submit educational material to the ASF in order for it to be cataloged?
- Who is going to be responsible for updating the website?
- How will those people be given access to the servers for the purpose of updating site?
9. Develop a Method of Tracking Website Downloads

Due to the current setup of the site it is not possible to track what material is being download as the case studies are being held “off site”. If providing a direct link to a case study download one possible method to achieve these metrics would be to track how many times a link were accessed. It is unclear whether or not Google Analytics has the functionality to track link activity.
References


Appendix A – Glossary of Terms

2D – Two Dimensional: An image represented by height and width but no depth.

3D – Three Dimensional: An image that has the appearance of depth and field

4D – Refers to 3D (height, width, depth) with the addition of time

5D – Refers to 3D (height, width, depth) with the addition of time and budget expenditures

AGC – The Associated General Contractors of America

BIM – Building Information Modeling. A subset of VDC. The process of developing and using a building information model. (NBIMS, 2007)

GIS – Geographic Information System

IPD – Integrated Project Delivery. A project delivery approach that integrates people, systems, business structures and practices into a process that collaboratively harnesses the talents and insights of all participants to optimize project results, increase value to the owner, reduce waste, and maximize efficiency through all phases of design, fabrication, and construction. (AIA, 2009)

VDC – Virtual Design and Construction.
Appendix B – Experimental Website Survey Request E-Mail

AGC BIMForum Academic Sub-forum Experimental Website

Morse, Eric J

Sent: Wednesday, August 19, 2009 12:38 PM

To: Salazar, Guillermo F.; jmessner@engr.psu.edu; cdossick@u.washington.edu; bstrenth@pittstate.edu; bakinci@cmu.edu; capanoc@wit.edu; Charles.Eastman@coa.gatech.edu; espeidel@calpoly.edu; fgould@rwu.edu; woo@msoe.edu; Lee.A.Fithian-1@ou.edu; mccallahan@ou.edu; mduPuis@sri-msn.com; mkenig@holder.com; mpuddico@norwich.edu; mrtato10@vt.edu; tom.rogers@nau.edu; wkymnell@csuchico.edu

Cc: sattian@auburn.edu; jprashaw@cohda.com; eaholt@purdue.edu; zigo@samfor.wash.edu; peggyhio@stanford.edu; alferieFFd@agc.org; matt.steere@mortenson.com; dsmith@nibs.org; brad.johnson@navigantconsulting.com; mmcdonald@nbbj.com; daniel.castro@coa.gatech.edu; wikerd@rginc.com; dlgb@ferris.edu; cyu@unt.edu; althea.arnold@unt.edu; John Tocci [jtocci@tocci.com]; Laura Handler [lhandler@tocci.com]

Ladies and Gentleman,

The Academic Sub-Forum had a successful breakout session at the May 28-29, 2009 AGC BIMForum meeting in Dallas, TX. At the meeting we discussed the potential benefits of creating an online resource of case studies for use by college and university professors interested in introducing Building Information Modeling (BIM) related concepts to their curricula, as well as those interested in strengthening their existing curriculum.

Since the AGC BIMForum meeting in May 2009, and as part of my junior qualifying project at WPI, I have been concentrating on the development and implementation of an online educational resource website. The site, although in its beginning stages of development, is ready for its first round of beta testing. I ask that you please take a moment to explore the website and make note of any potential issues you may have. A link to the experimental website has been provided below:

http://www.morse-eng.com/

Username: BIMForum
Password: test

In an effort to enhance the content and functionality of the website I ask that you also take a moment to fill out a brief, 10 question survey related to the new website. The survey contains simple questions regarding demographic information, effectiveness of web content, and website architecture. Your comments and suggestions are invaluable to the creation of a viable online BIM resource, so please be as thorough as possible. A link to the survey is also be posted on the experimental version of the Academic Sub-Forum homepage. For a direct link to our survey please use the following:


If you have any questions, comments, or concerns about the all new Academic Sub-forum experimental website please feel free to contact me directly at emorse@wpi.edu for assistance. Your prompt attention to this request will be high appreciated.

Thank you,

Eric Morse
Department of Civil and Environmental Engineering
Worcester Polytechnic Institute (WPI)
Class of 2010
Appendix C – Experimental Website Survey
WPI ~ Building Information Modeling

1. General Information

Estimated completion time for this survey is fewer than 10 minutes.

There are two parts to this survey:
Part 1 covers general information regarding your teaching practices.
Part 2 covers the functionality of the experimental website for the BIMForum Academic Sub-forum.

An asterisk (*) denotes a mandatory response.
You may leave any additional questions unanswered if they are not applicable.

Thank you for completing this survey. Your comments and suggestions are invaluable to the creation of a viable online BIM resource. If you have any additional comments or concerns please feel free to contact me directly at emorse@wpi.edu. Again, thank you very much for your time and effort in completing this survey.

Eric Morse
WPI '10

* 1. Demographic Information:

Name: 
College or University: 
Academic Program: 
City/Town: 
State: 
Email Address: 

* 2. Are you teaching any courses that require BIM related content? (Check all that apply)

☐ Planning on teaching BIM-related curriculum
☐ Currently teaching BIM-related curriculum
☐ Undergraduate Level
☐ Graduate Level

* 3. Do you use the case method for teaching any of your courses?

☐ Yes
☐ No
WPI ~ Building Information Modeling

* 4. Where do you typically find instructional material for your courses? (Check all that apply)
   - Books
   - Colleagues
   - Conferences
   - Internet
   - Working Professionals
   - Other (please specify)

* 5. Would you be interested in contributing BIM related coursework to the Academic Sub-forum’s website?
   - Yes
   - No
2. Academic Sub-forum Experimental Website

* 1. How useful is the concept of having a website dedicated to promoting and facilitating the adoption of BIM-related concepts in college curriculum to you?

- Very Useful
- Somewhat Useful
- Neither
- Not very Useful
- Useless

Are you aware of any other website which provide similar services to this experimental website? If so please list them here:

* 2. Overall, how would you rate the experimental website?

<table>
<thead>
<tr>
<th></th>
<th>Excellent</th>
<th>Good</th>
<th>Average</th>
<th>Poor</th>
<th>Very Poor</th>
<th>N/A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Content</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Layout</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Visual Appeal</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ease of Navigation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ability to Find Pertinent Information</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Additional Comments

* 3. Please provide any additional comments or suggestions that you may have pertaining to the Academic Sub-forum experimental website's architecture.
WPI ~ Building Information Modeling

4. Would you like to see the case study format improved?
- Yes
- No

Other (please specify)

* 5. How useful are the case studies presented on this site?
- Very Useful
- Somewhat Useful
- Neither
- Not very Useful
- Useless

Other (please specify)
Appendix D – Experimental Website Survey Actual Responses

Survey Part 1

Question 1: Demographic Information

- Construction Management
- Architectural Technology

Question 2: Are you teaching any courses that require BIM related content? (Check all that apply)

- No Additional Responses

Question 3: Do you use the case method for teaching any of your courses?

- No Additional Responses

Question 4: Where do you typically find instruction material for your courses? (Check all that apply)

- My own architectural practice

Question 5: Would you be interested in contributing BIM related coursework to the Academic Sub-forum’s website?

- No Additional Responses

Survey Part 2

Question 1: How useful is the concept of having a website dedicated to the promoting and facilitating the adoption of BIM-related concepts in college curriculum to you?

- Building SmartAlliance
- obviously the VICO site
Question 2: Overall, How would you rate the experimental website?

- You need to add more case studies (but not as part of your IQP)
- Everything I tried worked flawlessly. Need to put on the case studies whether or not they are being copywrited or can we copy them for educational purposes.
- KISS

Question 3: Please provide any additional comments or suggestions that you may have pertaining to the Academic Sub-forum experimental website’s architecture.

- None for now
- Great start.
- We need to have this site accessible to non-member faculty

Question 4: Would you like to see the case study format improved?

- Better Narratives associated to the slides
- Continued, great idea!
- We can always improve, but it’s best to get something out sooner than later.

Question 5: How useful are the case studies presented on this site?

- Need more cases in all categories
Appendix E – Experimental Website Analytical Data

www.morse-eng.com
Country/Territory Detail:
United States

Jul 22, 2009 - Aug 21, 2009
Comparing to: Site

This country/territory sent 28 visits via 9 regions in the "New Visitors" segment

<table>
<thead>
<tr>
<th>Region</th>
<th>Visits</th>
<th>% New Visits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Massachusetts</td>
<td>17</td>
<td>60.71%</td>
</tr>
<tr>
<td>Virginia</td>
<td>3</td>
<td>10.71%</td>
</tr>
<tr>
<td>California</td>
<td>2</td>
<td>7.14%</td>
</tr>
<tr>
<td>Texas</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Kansas</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Colorado</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Michigan</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Arizona</td>
<td>1</td>
<td>3.57%</td>
</tr>
<tr>
<td>Rhode Island</td>
<td>1</td>
<td>3.57%</td>
</tr>
</tbody>
</table>

Bounce Rate: 28.57%
22 pages were viewed a total of 134 times in the "New Visitors" segment

<table>
<thead>
<tr>
<th>Page</th>
<th>Pageviews</th>
<th>Unique Pageviews</th>
</tr>
</thead>
<tbody>
<tr>
<td>/index.html</td>
<td>33</td>
<td>22.22%</td>
</tr>
<tr>
<td>/asftcs/browse.html</td>
<td>28</td>
<td>16.18%</td>
</tr>
<tr>
<td>/asftcs/search.html</td>
<td>12</td>
<td>9.09%</td>
</tr>
<tr>
<td>/asftcs/visualization.html</td>
<td>10</td>
<td>6.05%</td>
</tr>
<tr>
<td>/<a href="http://www.morse-eng.com/index.html">http://www.morse-eng.com/index.html</a></td>
<td>7</td>
<td>4.04%</td>
</tr>
<tr>
<td>/asftcs/clash.html</td>
<td>8</td>
<td>6.06%</td>
</tr>
<tr>
<td>/asftcs/preconstruction.html</td>
<td>5</td>
<td>5.05%</td>
</tr>
<tr>
<td>/asftcs/main.html</td>
<td>5</td>
<td>5.05%</td>
</tr>
<tr>
<td>/asftcs/construction.html</td>
<td>3</td>
<td>3.03%</td>
</tr>
<tr>
<td>/asftcs/fabrication.html</td>
<td>3</td>
<td>3.03%</td>
</tr>
<tr>
<td>/asftcs/facilities.html</td>
<td>3</td>
<td>3.03%</td>
</tr>
<tr>
<td>/asftcs/interoperability.html</td>
<td>2</td>
<td>2.02%</td>
</tr>
<tr>
<td>/asftcs/laser.html</td>
<td>2</td>
<td>2.02%</td>
</tr>
<tr>
<td>/asftcs/misc.html</td>
<td>2</td>
<td>2.02%</td>
</tr>
<tr>
<td>/asftcs/safety.html</td>
<td>2</td>
<td>2.02%</td>
</tr>
<tr>
<td>/asftcs/uses.html</td>
<td>2</td>
<td>2.02%</td>
</tr>
<tr>
<td>/asftcs/f.html</td>
<td>2</td>
<td>2.02%</td>
</tr>
<tr>
<td>/search/results.asp?currentPage=28&amp;look_for=bim</td>
<td>2</td>
<td>1.01%</td>
</tr>
<tr>
<td>/search/results.asp?look_for=bim</td>
<td>2</td>
<td>2.02%</td>
</tr>
<tr>
<td>/asftcs/sustainability.html</td>
<td>1</td>
<td>1.01%</td>
</tr>
<tr>
<td>/search/results.asp?look_for=clash+detection</td>
<td>1</td>
<td>1.01%</td>
</tr>
<tr>
<td>/search/results.asp?look_for=simple+clash+detection</td>
<td>1</td>
<td>1.01%</td>
</tr>
</tbody>
</table>
Appendix F – AGC’s Recommended BIM Case Study Categories

Case Study Topics

The following topics should be covered. A topic should be considered covered if the case study meets the definition of the topic below. Highest priority should be given to topics illustrating collaboration, quantity take-offs during preconstruction, pre-ordering, coordination, and construction sequencing. For all topics, interoperability successes and problems should be clearly detailed.

Visualization (walk-through, coordination, constructability, design/detailing collaboration?)

- **Walk-Through** – Cases demonstrate the use of BIM to communicate design to end users of a facility.

- **Design Coordination** – Cases show how better visualization allowed architect and consultants to more effectively communicate and coordinate design issues before a contractor was involved.

- **Constructability** – Cases detail a collaborative effort between the design team and contractor to use BIM to pinpoint constructability issues during preconstruction.

- **Design/Detailing Collaboration** – Cases examine how shop drawings and detailing were completed quicker due to BIM visualization benefits and design team and contractor sharing of information.

Clash Detection:

Cases used to coordinate and complete design/detail/bid processes and contractor/subcontractor coordination.

Preconstruction:

Cases illustrating quantity take-off uses of BIM and subsequent effects on the value engineering process, as well as pre-ordering benefits.

Shop Fabrication:
Cases illustrating shop fabrication greatly increased or non-typical components fabricated in the shop versus on-site.

**Construction Management (scheduling, cost tracking, material status checking, logistics):**

- **Scheduling** – Case illustrate how schedule information was integrated into the model to better sequence the project.

- **Cost Tracking** – Cases show models tagged with cost information to track change orders and percent complete.

- **Material Status** – Cases demonstrate tracking of materials to decrease delays and increase “just-in-time” deliveries.

- **Site Logistics** – Cases illustrate improved use of site logistics through modeling efforts.

**Facilities Management:**

Cases illustrating which information, such as manufacturer details, sustainability features, and interoperability issues, was included in the model and how facilities managers utilize the model.

**Partial Uses:**

Cases illustrating projects where all stakeholders of the construction process did not participate in the modeling effort; for example, design team modeling in 3D, and contractors shop drawings in 2D. Cases showing how the absence of one party affected the full benefits of BIM.

**Safety:**

Cases illustrating the analysis of unsafe conditions virtually; for example, showing that a model was used to analyze the proximity of construction operations to a passersby.

**Laser Scanning:**

Cases illustrating how the scanning accomplished, who used the scans and how the scans were used, as well as the benefits to all stakeholders.
**Sustainability:**

Modeling energy, water, materials, and other LEED performance requirements.

**Interoperability**

Cases illustrating the trials and successes of modeling using interoperability concepts, and how others overcame complications of interoperability.

**Case Study Format**

The case method is a powerful learning model. Cases provide a context in which learners can practice BIM skills or explore management principles. The Harvard Case Method is a practical approach for analyzing, discussing, and writing about BIM cases. It shows how to classify cases according to the analytical task they require (solving a problem, making a decision, or forming an evaluation) and quickly establishes a base of knowledge about a BIM case. Examples of effective and ineffective BIM cases further reinforce people’s learning.

Experience is the best teacher, and the case method packs more experience into every hour of learning than any other instructional approach. That's why it forms the basis of learning at Harvard Business School, as well as many other universities around the world. In case discussions, students are introduced to the reality of decision-making, including incomplete information, time constraints, and conflicting goals, giving them first-hand experience in analyzing business situations. BIM case studies stimulate participants’ thinking, challenge their capabilities, and prepare them for future managerial decision making. It is designed to challenge participants by bringing them as close as possible to practical utilization of BIM in the real world.
Appendix G – Links

About the BIMForum Organization
http://www.bimforum.org/index.php?option=com_content&task=view&id=17&Itemid=31

Associated General Contractors of America – BIM Education Program
http://www.agc.org/cs/building_information_modeling

Autodesk University and College Classroom Curriculum
http://usa.autodesk.com/adsk/servlet/index?siteID=123112&id=8029689&linkID=9243097

Bentley Systems, Inc. Online Seminar Library
http://connected.bentley.com/

BIM Jet: BIM Resources
http://www.bimjet.com/Home/bim-resources-1

Building Smart Alliance Website for Collaborative Development
http://www.buildingsmartalliance.org/projects/active_projects.php

Georgia Tech BIM Resource Website
http://bim.arch.gatech.edu/

Graphisoft: ArchiCAD BIM Curriculum
http://www.graphisoft.com/education/curriculum/

Original BIMForum “mock-up” website
http://users.wpi.edu/~salazar/BIMForumAcademic/

Reed Construction: High Quality Free Parametric BIM Objects
http://smartbim.reedconstructiondata.com/

Second BIMForum “mock-up” website designed by John Tocci, Jr.
http://bimforum.pbworks.com/

Stanford University: Center for Integrated Facility Engineering
http://www.stanford.edu/group/CIFE/

U.S. General Services Administration – BIM Resources
http://www.gsa.gov/Portal/gsa/ep/contentView.do?contentType=GSA_OVERVIEW&contentId=20917

Whole Building Design Guide
http://www.wbdg.org/
Appendix H – BIMForum Academic Survey

BIMForum Academic Survey
Updated
July 17, 2007

Participating Academic Institutions

United States
- Arizona State University
- Carnegie Melon University
- Drexel University
- Lawrence Tech
- Pennsylvania State University
- Pittsburg State University
- Wentworth Institute of Technology
- Worcester Polytechnic Institute

International
- Technion - Israel Institute of Technology University
- Universidad Autónoma de Yucatán
- Universidade Católica Portuguesa

Is BIM formally taught or discussed in courses or projects?

- Yes: 82%
- No: 18%

At what level is BIM formally taught or discussed in courses or projects? (*)

- Undergrad and Grad
- Senior/Graduate
- Advanced Project Management course, Symbolic Product and Process Modeling course, and Industry Foundation Classes
- Undergraduate and Graduate Levels. 1-week module on freshmen course, 1 week module in AutoCAD course. 1 Graduate course, research, undergraduate and graduate projects
- 2nd and 3rd-year: We are preparing a Master in Digital Project, that integrates BIM.
- Intro
- Undergrad - 1st year compulsory course titled ‘Graphic Engineering Information’. Grad - ‘Computer Methods in Construction Management’
- BIM is taught in the 5th year of the professional Bachelor of Architecture degree (B Arch)

(*) Responses are not necessarily listed in the same order in which participant academic institutions are listed on the second slide

When did you start introducing BIM into your program?

- 1-2 years ago: 50%
- 2-5 years ago: 18%
- More than 5 years ago: 27%

How extensive is the BIM related activity in your academic program? (*)

- Discussions in Management classes in both undergrad and grad. Titles to front and Gra shepherd for undergrad students.
- Currently, not vary
- Note that a number of years ago the BIM concept ran under the more generic name of interoperability. We dedicated about 1/3 of a semester of a 3 cr. MS course to issues related to interoperability.
- For extreme, heavily incorporated into two courses.
- Primarily driven by one faculty but a couple of other faculty members are now starting to promote informal use by their students
- It is totally embedded in student’s architecture production
- Very
- In the undergraduate course, students have a few weeks module on modeling structures, producing drawings, measuring quantities, etc, using Revit Structures.
- In the initial stages
- We started to relate energy, lighting, and structure software with 3D-models.
- Covers design, cost estimating, planning and scheduling

(*) Responses are not necessarily listed in the same order in which participant academic institutions are listed on the second slide
How fast is BIM growing in your academic program? (*)
- Fast
- I expect it to grow quite rapidly, but we haven’t made a formal decision
- Students find jobs fairly easily with the skills they have, however, we do not have formal agreements with companies as such
- Very rapidly
- We anticipate fast growth
- The course is compulsory for all first-year civil engineering students
  Over the first two semesters that the course was offered, 165 students took the course
- The students use it for CAD only

Where are you heading in the short/long term? (*)
- More seminars and presentations by industry using BIM
- More has been introduced early in courses and build upon them in later courses
- We teach it as an integrating tool
- A full undergraduate course is now being discussed
- In the short term, the ambition is to make our students more competitive
  than students from other universities where BIM is not taught (majority)
  We do not know what the long term things are pretty much open in the designing aspect of BIM
  - short: introducing in all AEC-related classes
  - long: standardizing the whole arch program on BIM for AEC-related classes
- Towards intense use
- Short-term level: introducing BIM in the 2nd year undergraduate level
  - integrating energy, lighting, cost, structure, acoustics etc. analysis programs
  - Long-term level: everything must happen in the short-term level

What kind of software do you use? (*)
- ADT, Revit, Graphisoft, Timberline and PKI
- We have Revit and Microstation products available
- Revit, ArchiCad and Navisworks
- ArchiCad and Revit, Timberline precision estimating and Graphic Estimating, Graphisoft Constructor and Common Point 3D
- Autodesk REVIT, PRIMAVERA, AutoCAD, Timberline, MS Office, AutoCAD 3D
- Archicad 10
- AutoCAD, Revit, Desktop. Adobe etc... the list goes on and on
- Revit Structures and Tekla Structures
- Revit
- Revit, Bentley, Vectorworks, FormZ, EnergyScheming, Energy10, Studi, Radiance, Lumen, Lightart
- Revit, Cost Estimating, MS Project

How supportive is the software industry of your needs?

Does industry support your activities?

Are you or your students and/or other faculty involved in research in this area?
In which particular topics of research are your students and/or other faculty involved? (*)

- Use BIM in field operations
- We have had faculty involved in network security issues and fault detection as well as expert system work
- Electrical, HVAC, Generalization of the BIM concept
- Model Generation and Model Matching, Augmenting BIM to incorporate construction project variables
- Design Construction Integration and Engineering and Construction Management Information Systems
- Collaborative design
- IFC exchanges for pre-cast concrete facades, Modeling methods and schematics for cast-in-place concrete, BIM productivity and economic impact studies
- Applying US-American and European environmental requirements as part of an integrated design process with the support of BIM

(*) Responses are not necessarily listed in the same order in which participating academic institutions are listed on the second slide.
Appendix I – buildingSMART alliance Educational Baseline Study

Introduction

- Baseline and Compendium of College and University Efforts
- The project will establish a baseline for metrics from which we can measure progress in the future.
- The project will provide basic knowledge of schools and programs throughout North America for use by prospective students and support administrators and faculty in making decisions about future programs. It will also help identify programs being offered for employers seeking appropriately educated prospective employees to fit their needs.
- There are standards of education currently in place, but they are inadequate for teaching the new generation of practitioners. Therefore, significant change is anticipated. This is our hope that through the Alliance that change can be identified and coordinated.

Survey Instrument

- Survey fielded on ZOOMERANG.com
- Launched June 16, 2008
- Advertised through a myriad of sources
- Still Available

Results – WHAT?

- 93 Completed Responses
  - 3 Countries
    - 1 from Mauritius
    - 2 from Australia
    - 38 states (USA)
  - Schools
    - 68 Unique Schools/Universities
BIM in Education

Results – WHEN?

- Physical Plant: CSU-Sac
  - Capital projects over $6M require BIM design
- Academics: Most “Just adding BIM”
- Fresno State:
  - Recent $20M endowment, much earmarked for BIM curriculum development
- But, others like CSU-Chico:
  - Been doing BIM since before 2000
  - 4 sequential semesters of BIM courses

Results – HOW?, continued

- University of Cincinnati
  - BS in AET have BIM in all study courses
- Penn State
  - Computer Integrated Construction Research
    - www.ewr.psu.edu/pcr
- Virginia Tech
  - Working with Bentley, VR for safety, others
- University of Florida
  - BIMBuilding, Transportation Aggregation

Future

- Official Source: Whole Building Design
  Guide (www.wbdg.org)
- Informal Source: BIMwiki.com
  - http://www.bimwiki.com/About_BIMEducation/Schools
- Teaming for Research Grants?
- Common Education Principles?
- Baseline for “Accreditation?”
- Employer Focus

Conclusion

- Most schools are just starting to wade into
  the waters of BIM
  - Academic: Most just starting classes
  - Capital Projects: Writing BIM Roadmaps
  - Research: Slightly more developed, but only in pockets
- Need to work together to achieve the
  greatest good with most impact!