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# Technology-Enabled Content in Engineering Technology and Applied Science Curriculum: Implications for Online Content Development in Teacher Education

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***Abstract***

*This preliminary study compared the effects of technology-enabled courses and face-to-face instruction using student learning styles and student preferences for content types. Two groups of students enrolled in problem-based courses (one in the College of Engineering and the other in the College of Applied Science) were included in this quasi-experimental research. A survey was used to collect information about the students' preference for content types. Kolb's Learning Styles Inventory was used to measure student learning styles preferences. The results indicated an expected preference in the engineering technology disciplines for concrete experience over abstract conceptualization. Neither the delivery medium nor the content type (face-face or online) had any statistically significant impact on students' final performance. A significant finding was that both group profiles suggested differing needs for presentation of content and learning styles for students in the two colleges. The conclusion was that learning styles could influence content type preferences among students in either environment (face-to-face or online) but this hypothesis needs more research.*

As thousands of engineering students enter college classrooms each year, many often leave without achieving their full potential or dream to enter a career in Engineering. Research indicates that there is much speculation about why this cycle continues year after year. The retention of students in nearby majors, Science, Technical and Mathematics (STM) students looks very similar. Among the reasons for this attrition is speculation that using virtual and new communication technologies to expand teaching methods and content presentation types might reduce the attrition of engineering and science related disciplines or allow educators to better assess the needs of learning needs of students to determine their risk of leaving the engineering and science related disciplines prematurely.

Engineering science courses provide the backbone of both engineering degrees and engineering technology degrees. These courses also serve as the entry point into the engineering and engineering technology curriculum. Far too often, content in these courses is presented in teaching modalities that only appeal to a particular, limited group of learners. As a result, many students perform poorly and lose interest in the content areas (Pittman, 2002). A collaborative project was developed and performed at the University of Cincinnati to improve the teaching and learning in engineering science courses.

The National Science Foundation provided support for this project through a planning grant in the "Bridges for Engineering Education" program. This grant enabled the researchers to develop technology-enabled content, evaluate its effectiveness, and conduct this preliminary research study. The content was developed collaboratively

among the College of Engineering, the College of Applied Science, and the College of Education, Criminal Justice and Human Services. Content experts, instructional designers, and instructional technology experts contributed to the development of educational modules that were tested in courses at the University of Cincinnati (Pittman, 2005). During research and evaluation, researchers evaluated the effectiveness of the educational modules and the student satisfaction with the modules and conducted research to study compare the effects of technology-enabled courses and face-to-face instruction using student learning styles and student preferences for content types. Two groups of students enrolled in problem-based courses (one in the College of Engineering and the other in the College of Applied Science) were included in this quasi-experimental research. This paper reports the results of the research study conducted in this project.

## Background

The goals of the project included: (a) improvement in pedagogy that results in students' better comprehending concepts and discerning the relevance of the coursework, (b) articulation of this pedagogy for technology-enabled courses for dissemination to the engineering education community, and (c) development of improved collaboration in content development. While the project was developed around engineering science coursework at the University of Cincinnati, the methods and results have broader significance (Rutz, 2005). The findings from the research in this project were used to develop a model of technology-enabled education that can be replicated at other institutions and the results of the preliminary research can help inform educators from any discipline regarding efficacy of this type of initiative, but cannot be generalized due to study limitations. Limitations included the size of the sample, timeframe for the study, research design was not based on a random sample, and only descriptive statistics were reported.

## Conceptual Frameworks

### *Defining Learning Objects as Web-enabled Content (WEC)*

Instead of creating large file size content, code and graphics for a particular course, a possible solution is to break the whole content down to much smaller and manageable "byte" size objects that can be re-packaged and re-purposed into a variety of different courses (National University of Singapore, 2004). Several objects used in this project referred to web-enabled content (WEC) or digital learning objects (DLO) as "content type". Interactive modules housed simulations designed as web-enabled content. In addition to instructional technology, engineering, science and math courses, these learning objects can be used for other non-math-science disciplines in education to explain similar ideas. In this paper, the learning objects will be referred to as web-enabled content (WEC), which assumes the format of short learning tasks created using computer hardware, software, multimedia or other electronic communications tools (Wiley, 2000).

*Meaningful Web-enabled Content (WEC)*

For WEC to become more meaningful, they should be self-contained and reference a particular set of learning objectives. WEC should be independent. The objects can be used as a "stand-alone" or as a component for a larger course. Ideally, WEC should be re-usable for a variety of courses and in multiple contexts for multiple purposes. WEC should also be catalogued with descriptive information allowing them to be searched and identified easily.i

WEC is especially appropriate in interactive online course designs because it allows the instructor and the facilitator to differentiate instruction to a diverse group of learners. WEC is especially good in courses with high technical or complex content. Although we tend to think first about the sciences (mathematics, physics, biology and so on), this research indicates that other course content designs in the liberal arts and education can benefit from such digital objects to prepare future teachers to integrate instructional technology. Considering this, the question becomes how do we prepare preservice teachers and educators in non-technical fields to develop and use WEC in online instruction or in traditional instruction? First, the use of WEC must be purposeful. This means they should be connected to goals and objectives of the instructional content. It is not always necessary to create new WEC. There are e-reservoirs or portals of such digital learning objects in databases that can be used "as is" or adapted for special purposes. However, similar to selecting software or hardware, teachers must understand how to identify the most appropriate WEC or when to create their own.

## Methodology

*Research Questions*

The guiding question in this study was "what effect did technology-enabled courses and traditional (face-to-face) instruction have on student preferences for content type based on their learning style preferences?" Other sub-questions included: (a) How was the preferred WEC–M identified? (b) Which learning styles were more prevalent in CAS and COE student groups? (c) What content types emerged as strongest or weakest in the instructional design, delivery system and research design in this project? (d) How was faculty prepared to integrate the WEC-M into existing instructional designs as prescriptive linking course material for the selected course modules? (e) What implications emerged for planning technology-enabled content in teacher education or other disciplines? (f) What skill sets and knowledge domain needs emerged that could contribute knowledge preparing preservice teachers and educators to effectively incorporate integrate digital prescriptive objects or WEC-M in the classroom? The discussion of these questions was not derived solely from the data collection but inferences were drawn and shared in the implications and conclusions.

Project Activities in the Study

Major activities of the project included the development of content, assessment of student learning styles, use of technology-enabled content in courses, evaluation of student learning and engagement, and faculty development.

Development of Content

Engineering science content was developed to appeal to a variety of student learning styles. The various modes of instruction developed during the project were categorized as:

- Read It – text and illustrations to appeal to visual learners / linguistic learners
- Watch It – streaming media presentation to appeal to visual learners / auditory learners
- Visualize It – animations to appeal to spatial learners / visual learners
- Try It – active exercises to appeal to kinesthetic learners / active learners

Content was developed to support a course in Basic Strength of Materials offered in the College of Engineering and a course in Flexible Automation offered in the College of Applied Science. The content was developed in a manner that allowed it to be delivered via the Web or through a CD.

Guidelines established for content creation to ensure instructional systems design appropriate for technology-mediated education were used. These guidelines were developed by the project manager, collaborators from the College of Education, and the participating faculty. An example of these guidelines is shown in Figure 1.

Material was developed by graduate assistants working with faculty, instructional designers, and the project manager. The new materials were developed to be a supplement and / or extension of the “traditional” materials. Animations and active exercises were derived from materials presented in the textbooks to be consistent with that resource. Streaming media presentations and web-based text and graphics were derived from both the course text and other standard texts to provide a richer resource.

The content developed during this project was provided as supplemental materials to students in traditional courses. Students were not required to use the digital material but they were encouraged on multiple occasions to make use of the materials to help learn the concepts. Moreover, the technology-enabled content was always available to the students via the Web or a CD.

Figure 2 is an illustration of the content available to students through the Blackboard course management system. Figure 3 is an illustration of the "Watch It" streaming media presentation. Figure 4 is an illustration of the "Try It" interactive

Technology-Enabled Engineering Science Content

"Try It" Content Development Guidelines

This module allows students to interact with the content to the greatest degree possible. It is intended to support active learning and student inquiry.

**Module contains**:
1. Description of the content of the section and a procedure for using the module
2. Physical model and a graphic representation
3. Interactive exercise that allows students to manipulate variables and see the outcomes of this manipulation
4. Discussion of what happens for each interaction
5. Discussion of the underlying principles

**Description**
A brief summary of the topic covered (e.g. stress), a cross reference to the section in the textbook, and an explanation of how the module works. This explanation should provide clear instructions on how parameters are manipulated and how the student receives feedback. The explanation should also inform students of any options they have and how to get help if they need it.

**Models**
To provide a real world context, the module should first introduce a familiar concept or situation for which the topic is applicable (e.g., a bridge). A graphical representation such as a free body diagram should then be shown.

**Interactive Exercise**
Students are able to change various aspects of the model and see the results of these manipulations. Clarity is very important – there must be an understandable connection between cause and effect.

**What Happened**
An explanation of the cause and effect should be given (e.g., increasing the load on the bridge caused the stress to increase).

**Underlying Principles**
The cause and effect discussed above should be related to the underlying principles being presented. This will typically be an explanation of the governing equations and which variables in the equations were involved in the manipulations.

exercise. Figure 5 is an illustration of the "Visualize It' animation.

***Figure 1*. Try-It Content Development Guidelines.**

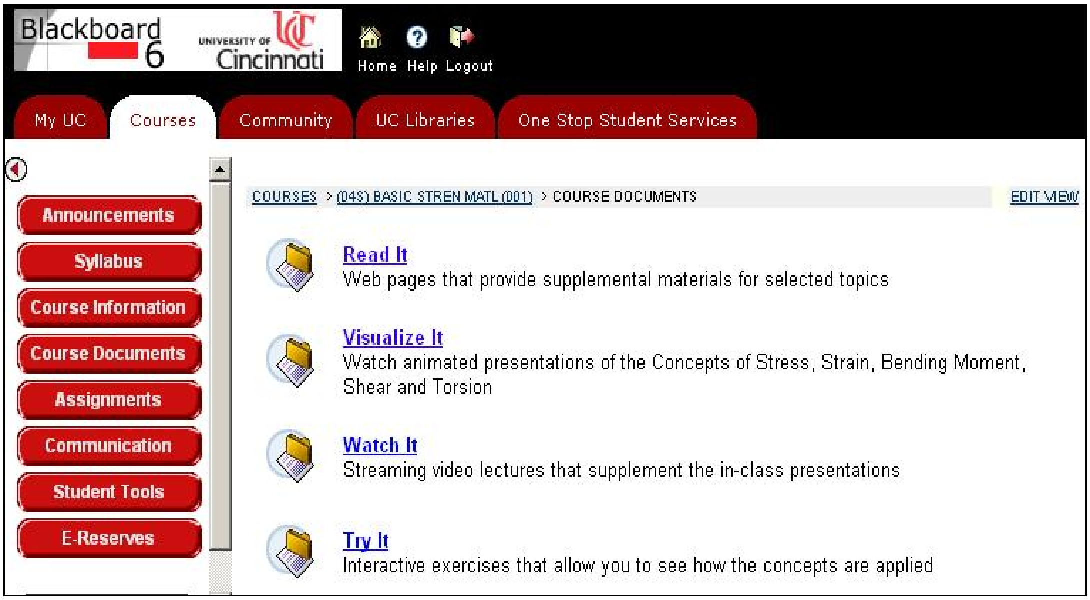


***Figure 2*. Technology-Enabled Content.**

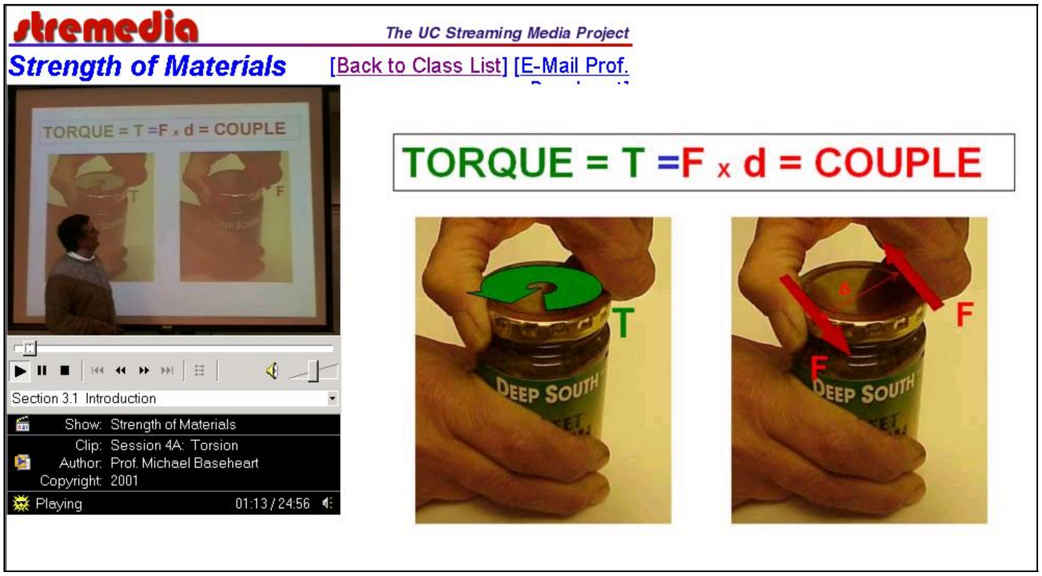


***Figure 3*. Streaming media example (digital movie).**

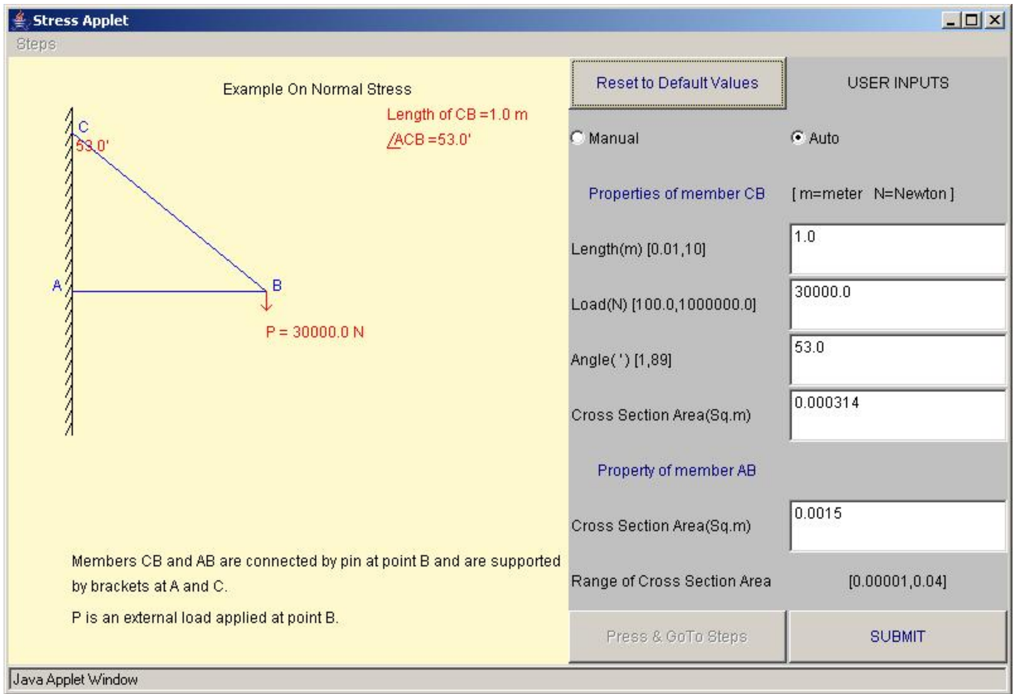


*Figure 4*. **Example of interactive exercise.**

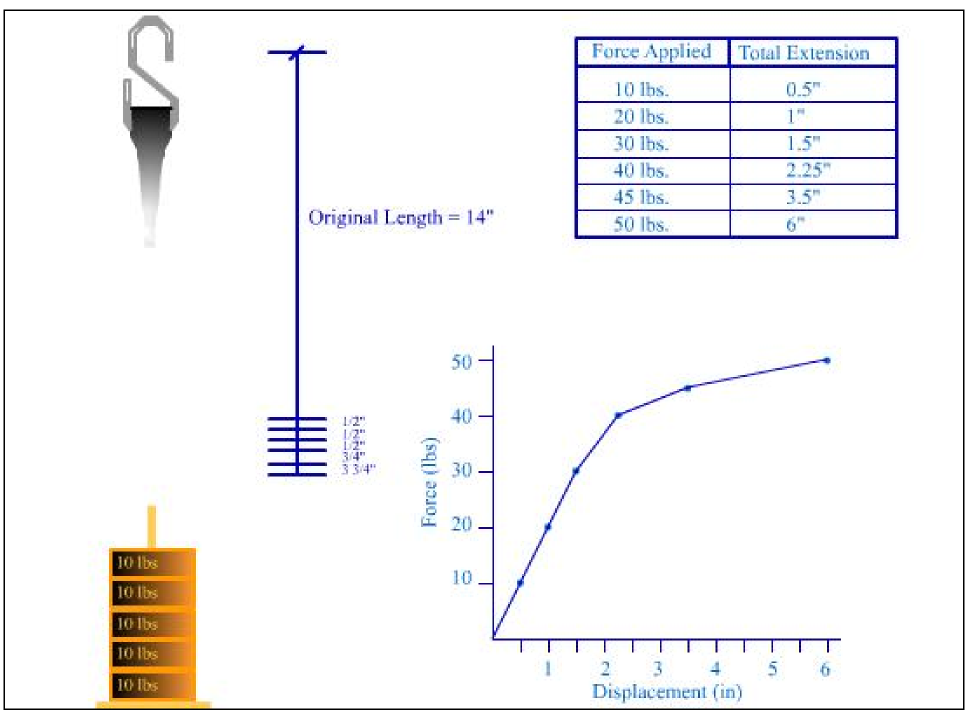


*Figure 5.* **Example of interactive animation.**

*Assessment of Student Learning Styles*

Kolb's Learning Styles Inventory (1984) was used as a measure of student learning styles preferences. Students in the Basic Strength of materials course and the Flexible Automation course completed this instrument. In addition, a large sample of engineering technology students were administered this instrument to provide a robust data set to compare with an earlier compiled data set of engineering students.

Kolb's method describes four different learning modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation (Kolb, 1984). These are illustrated in Figure 6. David Kolb's theory of learning style proposes four groups. The convergent learning style (CNV) relies primarily on the dominant learning abilities of abstract conceptualization and active experimentation. The strength of this learning style is in problem solving, decision-making and practical application of ideas. Ideas are organized for solving problems using deductive reasoning. The divergent learning style (DIV) relies on concrete experience and reflective observation. The greatest strength of this learning style is in being able to organize information from a variety of perspectives. Assimilation learning styles (ASM) are identified by abstract conceptualization and reflective observation. The strength of this style is in inductive reasoning and the ability to create theoretical models. The fourth style, accommodation (ACC), emphasizes concrete experience and adaptive experimentation. The strength of this style is in carrying out plans and tasks, risk taking and action.

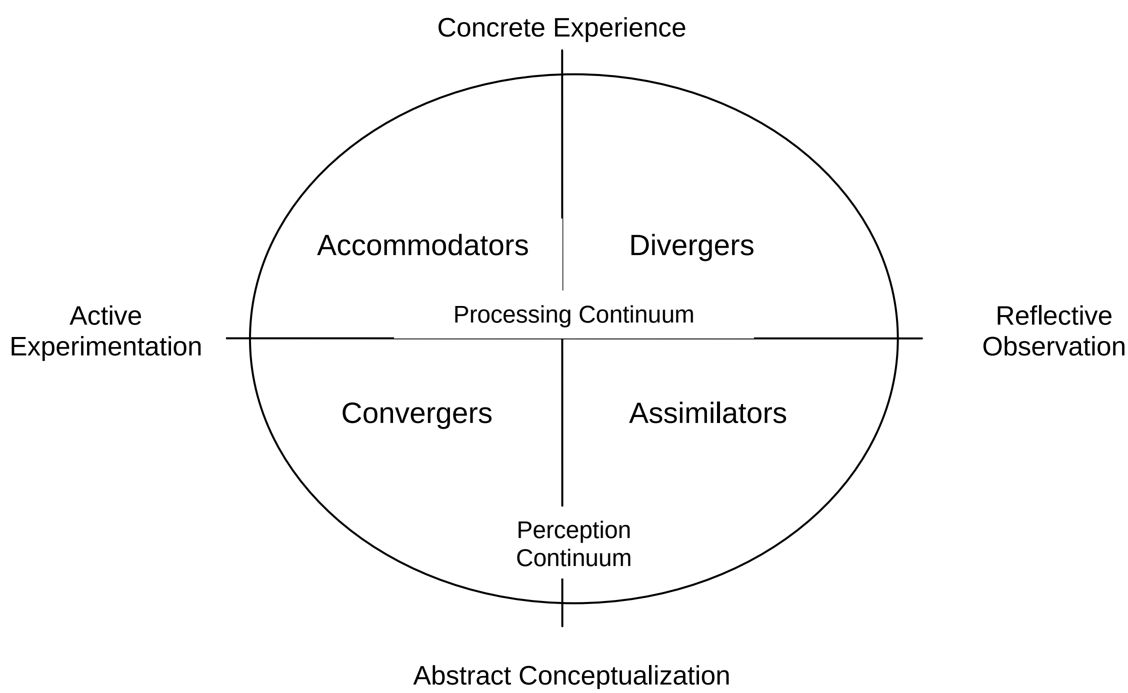


***Figure 6*. Kolb's learning styles**.

*Use of Web-Enabled Content*

Evaluation of student use of WEC and materials was studied using a pseudo longitudinal format focusing on cognition and authentic assessment. The researchers and instructors by tracked students' performance and achievement in the traditional 2003 version of the course and comparing it with the 2004 version of the course taught by the same instructors. A traditional grading system was used for both course formats, which included a numeric grading scale for evaluating learning exercises and exams. The use of the WEC content tracking included the number of students using the WEC and materials (M), the number of times students accessed (and assumed used) the WEC-M, the students' performance on activities and examinations.

*Evaluating Student Learning and Engagement*

Evaluating student learning and engagement included more of the affective domain. Using the same pseudo-longitudinal (comparative) design the variables were expanded to include attitudes and perceptions about WEC-M. A survey was developed to collect information about students' perceptions about the learning content, contributions of specific WEC-M (e.g. streaming video), interactive exercises, engaging and interesting aspects of WEC, enrollment preferences for traditional or WEC-M courses, and basic strength of materials. In addition, the researchers compared the profiles of CAS and COE students by analyzing Learning styles profiles, preferences for content types (traditional or WEC-M) and classroom performance. The findings are shared in the methodology section of this paper.

*Faculty Development*

Two professional development workshops were presented to faculty of the College of Engineering and the College of Applied Science. Table 1 summarizes the material presented at the workshops.

**Table 1**

***Faculty Development Workshops***

| Workshop 1 – Pedagogy in Engineering and Technology Education | Workshop 2 – Effective Use of Technology in Engineering and Technology Education |
|---|---|
| Topics: | Topics: |
| Introduction to learning styles | Technology and learning styles |
| Key teaching behaviors | Technology available to faculty |
| Elements of instructional design | Technology to support learning |
| Pragmatic applications | Pragmatic applications |
| Participants: 13 | Participants: 12 |

*Sample Selection and Description*

A purposeful, convenience-sampling strategy resulted in 12-13 faculty members from College of Applied Sciences (CAS) and College of Engineering (COE) and 42 students from CAS/COE participating in this quasi-experimental research.

*Materials and Methods*

Before administering the Kolb Learning Styles Inventory and the instructional survey to the students participating in this study, both tools were approved by the University's Human Subjects Board at the University of Cincinnati, Cincinnati, Ohio. Participation in the study was voluntary, and the students received no incentive to participate. The 42 students participating in this study were considered adults based on the premise that their decisions to attend school and participate in the study was of their own free will and in no way would affect their grade or standing in the program. All survey and assessment activity was carried out during class time. The only data included in the study is that of students present during the data collection activity during the class period.

*Data Collection and Analysis*

An evaluation instrument was developed to determine student use of the technology-enabled content, student satisfaction with the various types of content, and student preferences regarding traditional vs. technology-enabled content. This instrument was administered several times throughout the term. Student performance was measured by final course grade. Class average grades for traditional and the technology-enabled

course presentations were compared. Due to the small size of the sample, only descriptive statistics were used to analyze the findings.

## Findings

In this section findings are presented to respond to the questions presented in the introduction. Table 2 compares the Learning Styles Inventory (LSI) data for students enrolled in the courses using the technology-enabled content. Table 3 compares the LSI data for the larger data sets of engineering technology students and engineering students. The results indicate an expected preference in the engineering technology disciplines for concrete experience over abstract conceptualization. The researchers did not expect to find as "balanced" a profile in the College of Applied Science as the one that emerged. The profiles suggest differing needs for presentation of content and learning styles for students in these two colleges.

**Table 2**

***LSI Categories – Students in Technology-Enabled Courses in the Project***

| LSI Category | Engineering Technology | Engineering | Percentage of Total Profiles<br><br>N= 42 |
|---|---|---|---|
| Accommodators | 3 | 0 | 7.1 |
| Divergers | 1 | 1 | 4.8 |
| Assimilators | 10 | 12 | 52.4 |
| Convergers | 5 | 10 | 35.7 |
| N=42 | 19 | 23 | |

In the analysis of student learning styles 19 CAS profiles and 23 COE student profiles were studied. The findings revealed three Accommodators from CAS and none from COE or 7.1 percent of students; one Diverger from CAS and one from COE or 4.8 percent of students; 10 Assimilators from CAS and 12 from COE or 52.4 percent of students; and five Convergers from CAS and 10 from COE or 35.7 percent of students. Summary, 88.1percent of CAS and COE students are Assimilators or Convergers. The percentage of Divergers and Accommodators was low for both groups.

**Table 3**

***LSI Categories – Students in the College of Applied Science vs. College of Engineering***

| LSI Category | Engineering Technology | Engineering |
|---|---|---|
| Accommodators | 30 (21%) | 46 (10%) |
| Divergers | 31 (22%) | 39 (9%) |
| Assimilators | 46 (32%) | 182 (40%) |
| Convergers | 36 (25%) | 189 (41%) |

Table 3 reports the results from a survey of the general student population in the Colleges of Applied Science (Engineering Technology (CAS) and the College of Engineering (COE) provide a descriptive profile of learners based on Kolb's learning preferences inventory. Eighty-one percent of Engineering (COE) students are Assimilators and Convergers while only fifty-seven percent of CAS students are Assimilators and Convergers. Both groups report a smaller percentage of Divergers and Accommodators. This information provided an anchor for studying the learning styles and content type preferences of students participating in this project.

*Evaluation of Student Learning and Engagement*

For this NSF research, it was not feasible to quantitatively assess improvement in test or class grades based on the use of the technology-enabled content; therefore the grading scales and descriptive statistics are used to report changes in student performance and use of WEC in learning and course engagement activities. Considering this limitation, there remained a number of assessments that could be made. Table 4 lists the grades for the Flexible Automation course during the project period (Spring '04) and the year before when the same course was taught by the same instructor. The standards university 100-point grading scale was used to assign student grades.

**Table 4**

***Students Exam Grades for Flexible Automation Course***

| Term | Exam 1 | Exam 2 | Exam 3 | Course Grade | Change from Traditional to WEC-M |
|---|---|---|---|---|---|
| Spring ‘04 | 95.1 | 89.8 | 82.5 | 89.2 | >2.4 |
| Spring ‘03 | 87.3 | 92.6 | 79.9 | 86.8 | |
| Change | | | | | Increase |

Table 5 lists the grades in the Basic Strength of Materials course for students using the technology-enabled content and for students in another section of the course (taught the same term) who did not have access to this content.

**Table 5**

***Students Exam Grades for the Basic Strength of Materials Course***

| Class | Exam 1 | Exam 2 | Final | Final Course Grade | Change from Traditional to WEC-M |
|---|---|---|---|---|---|
| Technology-Enabled (2004) | 69.1 | 77.2 | 70.1 | 74.8 | <4.4 |
| Traditional (2003) | NA | NA | NA | 79.2 | Decrease |

Student exam grades for 2003 and 2004 were compared based on three exams and the final grade. There was missing data for the traditional course in 2003 and only the final course grade could be compared. The final course grade for WEC-M was 4.4 scale point lowered than the traditional final course grade and was not considered significant given the presence of uncontrolled variables in this pseudo-longitudinal model. The analysis did not lend itself to a statistical test to determine the essence of this difference in final grades between the traditional and WEC-M courses. In general terms, there is no significant difference between course average grades for the technology-enabled courses and those presented in the traditional method.

Student evaluations of the efficacy of the technology-enabled content and other course related parameters are indicated below. A modified Likert scale with ratings from 1-5 was used with one indicating strongly disagree, three as neutral and five strongly agree. Three evaluations were administered: one toward the beginning of the term, one around mid-term and one at the completion of the term.

**Table 6**

***The Animations Helped Me Learn the Material***

| | COE | CAS |
|---|---|---|
| Beginning | 3.1 | 3.4 |
| Mid-term | 2.9 | 3.5 |
| Final | 3.1 | 3.4 |

**Table 7**

***The Web Pages Helped Me Learn the Material***

| | COE | CAS |
|---|---|---|
| Beginning | 3.1 | 3.2 |
| Mid-term | 3.0 | 3.9 |
| Final | 2.9 | 3.7 |

**Table 8**

***The Streaming Video Helped Me Learn the Material***

| | COE | CAS |
|---|---|---|
| Beginning | 3.0 | 3.7 |
| Mid-term | 2.4 | 4.6 |
| Final | 3.0 | 4.1 |

**Table 9**

***The Interactive Exercises Helped Me Learn the Material***

| | COE | CAS |
|---|---|---|
| Beginning | 3.0 | 3.1 |
| Mid-term | 3.1 | 4.1 |
| Final | 3.0 | 3.8 |

**Table 10**

***The Material for the Course is Interesting and Engaging***

| | COE | CAS |
|---|---|---|
| Beginning | 3.6 | 3.9 |
| Mid-term | 3.4 | 4.0 |
| Final | 3.6 | 3.9 |

**Table 11**

***Given a Choice, I would enroll in a Technology-Enabled Course***

| | COE | CAS |
|---|---|---|
| Beginning | 3.5 | 4.2 |
| Mid-term | 3.3 | 4.2 |
| Final | 3.2 | 4.3 |

**Table 12**

***Compared with Other Instructors I've had, the Instructor for This Course Was Effective***

| | COE | CAS |
|---|---|---|
| Beginning | 3.9 | 4.1 |
| Mid-term | 4.3 | 4.3 |
| Final | 4.0 | 4.2 |

**Table 13**

***I Would Prefer a Traditional Course***

| | COE | CAS |
|---|---|---|
| Beginning | 3.1 | 3.0 |
| Mid-term | 2.9 | 2.4 |
| Final | 3.0 | 3.1 |

**Table 14**

***The Web-Based Materials were a Helpful Addition to the Course***

| | COE | CAS |
|---|---|---|
| Beginning | 2.8 | 3.7 |
| Mid-term | 3.2 | 3.9 |
| Final | 3.3 | 3.8 |

The tables that follow provide an indication of the number of individuals in the two courses who used the technology enabled content and the number of times each was used.

**Table 15**

***Flexible Automation: Number of Students Using Technology-enabled Materials***

| | Web pages | Streaming Video | Animations | Interactive exercises | Total |
|---|---|---|---|---|---|
| Beginning | 12 | 8 | 6 | 7 | 33 |
| Mid-term | 11 | 9 | 9 | 6 | 35 |
| Final | 13 | 6 | 7 | 5 | 31 |
| Total | 36 | 23 | 22 | 19 | 99 |
| Percent | 36.3 | 23.2 | 22.2 | 19.1 | |

For the Flexible Automation course, the number of Students Using Technology-enabled materials suggests resulted in 59.5 percent of students indicating a preference for Web pages and Streaming video and 41.3 preferring Animations and Interactive exercises.

**Table 16**

***Number of Times Materials Were Used***

| | Web pages | Streaming Video | Animations | Interactive exercises | Total WEC-M |
|---|---|---|---|---|---|
| Beginning | 73 | 24 | 22 | 28 | 147 |
| Mid-term | 91 | 32 | 21 | 26 | 170 |
| Final | 77 | 11 | 21 | 30 | 139 |
| Total | 241 | 67 | 64 | 85 | 456 |
| Percent | 52.8 | 14.0 | 14.0 | 18.6 | |

The number of time materials was used suggested a strong preference for Web pages and a modest preference for Streaming Video 14.7 percent, Animations 14.0 percent, and Interactive exercises 18.6 percent slightly higher than Animations.

**Table 17**

***Basic Strength of Materials: Number of Students Using Technology-enabled materials***

| | Web pages | Streaming Video | Animations | Interactive exercises | Total |
|---|---|---|---|---|---|
| Beginning | 9 | 12 | 11 | 8 | 40 |
| Mid-term | 14 | 12 | 19 | 12 | 57 |
| Final | 14 | 14 | 14 | 13 | 55 |
| Total | 37 | 38 | 44 | 33 | 152 |
| Percent | 24.3 | 25.0 | 28.9 | 21.7 | |

The Basic Strength of Material was evaluated by analyzing the number of Students Using Technology-enabled materials. These results suggested students had no strong preference for any of the four content types. However, Animations showed the highest preference with 28.9 percent and Interactive materials the least with 21.7 percent of the access time for objects reportedly used by students.

**Table 18**

***Number of Times Materials Were Used***

| | Web pages | Streaming Video | Animations | Interactive exercises | Total |
|---|---|---|---|---|---|
| Beginning | 44 | 26 | 28 | 29 | 127 |
| Mid-term | 58 | 24 | 36 | 32 | 150 |
| Final | 56 | 27 | 34 | 38 | 155 |
| Total | 158 | 77 | 98 | 99 | 432 |
| Percent | 59.4 | 17.8 | 22.6 | 22.9 | |

Most students indicated they did not have a preference in the type of content. However, in the analysis of frequency for accessing content Web pages were accessed almost 60 percent of all WEC-M. The least accessed WEC was streaming video. Animations and Interactive materials were closely ranked. However, COE student ranked Web pages as the least preferred WEC-M and CAS students ranked it very close to Video streaming.

For those who did express preferences, the following tables indicate the preferences for type of content. In general, there was no significant preference for one type of content over another based on the descriptive analysis and interpretation of the frequency data.

**Table 19**

***COE Preferences for Type of Content***

| | Web pages | Streaming Video | Animations | Interactive exercises | Total |
|---|---|---|---|---|---|
| Beginning | 0 | 2 | 1 | 1 | 4 |
| Mid-term | 1 | 4 | 3 | 2 | 10 |
| Final | 2 | 3 | 4 | 4 | 13 |
| Total | 3 | 9 | 8 | 7 | 27 |
| | 11.1 | 33.0 | 29.6 | 25.9 | |

In the analysis of content preferences by frequency of selection by COE students, a preference for streaming video, animations, and interactive learning exercises. COE students indicated these preferences as follows: 11.1 percent Web pages, 33.0 percent Streaming video, Animations 29.6 percent, and Interactive exercises 25.9 percent. COE preferences for content type based on usage were not that different from CAS. The most preferred was Animations, second was Interactive exercises and the least was Web.

**Table 20**

***CAS Preferences for Type of Content Frequencies***

| | Web pages | Streaming Video | Animations | Interactive exercises | Total |
|---|---|---|---|---|---|
| Beginning | 3 | 1 | 1 | 3 | 8 |
| Mid-term | 0 | 2 | 1 | 3 | 6 |
| Final | 2 | 2 | 2 | 1 | 7 |
| Total | 5 | 5 | 4 | 7 | 21 |
| | (23.8) | (23.8) | (19.0) | (33%) | |

In the analysis of content preferences by frequency of selection by CAS students, a preference for Interactive learning exercises, web pages, and, streaming video were more often preferred than animations. The CAS students indicated those preferences as follows: 33 percent Interactive activities, 23.8 percent Web pages, 23.8 percent Streaming video, and 19.0 animations.

In summary, preferences for Animations and Web pages was showed the greatest difference and most inconsistency in content type preferences between the two groups for content preferences based on the frequency analysis which was limited to descriptive data analysis and inferences by the researchers.

## Discussion

This preliminary study compared the effects of technology-enabled courses and face-to-face instruction using student learning styles and student preferences for content types. Two groups of students enrolled in problem-based courses (one in the College of Engineering and the other in the College of Applied Science) were included in this quasi-experimental research. A survey was used to collect information about the students' preference for content types. Kolb's Learning Styles Inventory was used to measure student learning styles preferences. The results indicated an expected preference in the engineering technology disciplines for concrete experience over abstract conceptualization. Neither the delivery medium nor the content type (face-face or online) had any statistically significant impact on students' final performance. A significant finding was that both group profiles suggested differing needs for presentation of content and learning styles for students in the two colleges. The conclusion was that learning styles could potentially influence content type preferences among students in either environment (face-to-face or online) but this hypothesis needs more research. Preliminary findings from this small sample suggests that most students indicated no strong preference for content type and their performance did not increase or decrease significantly for either course based on their Kolb learning style preference. This was a

worthy outcome to note when considering the descriptions of the convergent and assimilation learning styles. As discussed earlier, the convergent learning style (CNV) usually relies primarily on the dominant learning abilities of abstract conceptualization and active experimentation. Ordinarily, this condition, which emerged in over half of the sample, would indicate a strong preference for content that required problem solving, decision-making and practical application of ideas. The Assimilation learning styles (ASM), which, was the second greatest preference is identified by students' preference for content that requires abstract conceptualization and reflective observation allowing the learner to exercise inductive reasoning and appreciation for the ability to create theoretical models. Taking these outcomes and findings into consideration, perhaps there are some interactions between social aspects of WEC-M learning environment and learning styles in instructional environment that could affect students' preference for content type or the delivery system that was not unveiled due to the design of this study. Considering this finding, an emergent research question was about how the Kolb findings or results might look in a different learning styles inventory.

Initially, during the search for an appropriate LSI, the Canfield Learning Styles Inventory (CLSI) emerged as another possibility for testing the hypothesis. Research suggests that the CLSI could be relevant in this discussion as we think about how to expand understanding of the preliminary findings because the scale has demonstrated some merit for use in distance learning studies because it attempts to measure student preferences under variable environmental conditions. Included in the CLSI are such constructs as student's need for affiliation with other students and instructor, and the student's need for independence or structure. Another LSI that we explored was the Grasha-Reichmann Student Learning Style Scales (GRSLSS) that might also be appropriate for assessing student learning preferences in a college-level distance learning setting. The GRSLSS (Grasha, 1996; Hruska-Riechmann & Grasha, 1988) is based on criteria suggested by James and Gardner (1995) was chosen as the tool for determining student learning styles in a similar study. Research suggests that the GRSLSS is one of few instruments designed specifically for use with senior high school and college/university students. A second rationale is that the GRSLSS uses a scale that was designed for distance learning settings. The scale is focused on how students interact with the instructor, other students, and with learning in general. In other words, the scales may address key distinguishing features of asynchronous distance learning courses such as the relative absence of social interaction between instructor/student and student/student. Third, it seems that the GRSLSS could promote an optimal teaching/learning environment by helping faculty design courses and develop sensitivity to student/learner needs, an important consideration for teachers and teacher educators. Fourth, the GRSLSS appears to promote understanding of learning styles in a broad context, spanning six categories.

The modules in this project were not implemented in a totally distance learning environment but rather an e-learning support system for traditional teaching or a blended environment. For example what would happen if the same study were conducted using LSI assessments with preservice teachers in teacher education math and science programs in comparison to engineering students preferences for learning. Do students who enter teacher education differ significantly in learning styles and preferences in instruction supported by online strategies such as the ones presented in this model and study?

What researchers do know is that different social dynamics could represent important unknown differences between distance learning and equivalent on-campus environments. However, in studying the GRSLSS, CLSI and Kolb's LSI, all create a range of applicability for learning styles consideration in instruction design and content delivery... This learning style "stereotyping" may be convenient for statistical analysis and planning, but must be cautiously applied to reduce the possibility of not allowing students the opportunity to develop weaker skills or explore unused learning preferences.

Furthermore, the Kolb LSI, used in this study is primarily a cognitive learning preference instrument, and may not fully take into account social preferences that might be more or less important to teachers or educators. This dimension could represent a key distinction between learning preferences by students in distance education and traditional classrooms.

## Implications for Teacher Education

A number of learning styles instruments were examined in the conduct of this study before selecting the Kolb's. The theory behind the Kolb's scale suggests that students possess all of six learning styles, to a greater or lesser extent. This type of understanding could expand the learning style spectrum and considerations for planning discipline- specific online courses or components as we consider testing the hypothesis using other LSIs. This type of research would perhaps provide a rationale for conceptualizing new instructional designs and strategies that stimulate and help preservice teachers understand and develop underused learning style areas thus addressing diversity in the classroom for a greater number of students (Pittman, 2003).

## Summary

The findings for two groups of students enrolled in problem-based learning modular courses in the College of Engineering Technology and the College of Applied Science were included in this quasi-experimental research. A survey was used to collect information about the students' preference for content types. Kolb's Learning Styles Inventory was used to measure student learning styles preferences. Before selecting Kolb's two other LSIs were examined during the literature review. The results of this preliminary study indicated an expected preference by students in the engineering technology disciplines for concrete experience over abstract conceptualization. Although there were not statistical tests to identify a correlation between the LSDI and WEC-M preferences, the descriptive data analysis inferred that neither the delivery medium nor the content type (face-face or online) had any statistically significant impact on students' final performance. An important observation was that both group profiles suggested differing needs for presentation of content and learning styles for students in the two colleges. In general terms, there was no observed difference between course average grades for the technology-enabled courses and those presented in the traditional method. The conclusion was that learning styles could influence content type preferences among students in either environment (face-to-face or online). Further research is needed to guide designing technology-enabled content for online learning environments, especially in teacher education.

## Conclusions

This preliminary study compared the effects of technology-enabled courses and face-to-face instruction using student learning styles and their preferences for content types and reported how the preferred WEC–M identified and found no significant relationship between a student learning style preference and preference for WEC-M or traditional content. Although, Web pages and Interactive materials emerged as strong preferences some students the data analysis did not associate any obvious or statistical relationship between the two variables. This does not mean that one does not exists but rather highlights a limitation of the research. The most convincing evidence of a potential relationship between LSI and WEC-M was found the data on student frequency or access and use of the WEC-M. The findings from this study are preliminary and based on a small convenient sample. To fully test the hypothesis and expand this study or to generalize the results, a larger random sampling strategy is recommended.

Clearly, if teacher educators and students are to understand how to connect these new resources to existing pedagogy and belief systems new instructional design models and ongoing professional development will be required. The implications from the findings indicate an immediate need for more planning and research about how to integrate technology-enabled content in teacher education or other discipline.

## Future Research

To replicate or expand this preliminary study in the future, the research design must be modified and expanded to include an empirical methodology centered on identifying the new skill sets and knowledge domain needs, a random sampling design, and a more extended time period. An empirical model could be used to test the hypothesis that there is no relationship between LSI and WEC-M of students when it comes to their preference for traditional or web-enhanced courses or instructional designs. This new information could contribute knowledge restructuring teacher education in an increasingly online learning environment and help preservice teachers and educators as they attempt to effectively integrate prescriptive digital objects or WEC-M in the classroom.

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## Participant Researchers

Richard Miller, College of Engineering, is the instructor for the Basic Strength of Materials course in which the technology-enabled content was used. Dr. Miller provided guidance on the development of the materials, their implementation and the evaluation of their effectiveness.

Max Rabiee, College of Applied Science, is the instructor for the Flexible Automation course in which the technology-enabled content was used. Dr. Rabiee provided guidance on the development of the materials, participated in the development of materials, implemented the materials and helped guide the evaluation of the effectiveness of the materials.

Ted Fowler, College of Education, Criminal Justice, and Human Services is an accomplished educator and researcher. Dr. Fowler contributed his expertise to the development of the technology-enabled materials and the pedagogy for the project. His primary contribution was leading two faculty development workshops.

Eldhose Stephan, Civil Engineering and Kirtimaan Rajshiva, Computer Science, are graduate students in the College of Engineering who contributed significantly to the development of the technology-enabled content.

[i] A listing of links to Digital Libraries is provided to clarify the meaning embedded in WEC and to demonstrate how widely available WEC is for educators to access and integrate into new instructional designs and instructional methods. Furthermore, the repository examples provide a look into the range of formats for web-enabled content or what some call digital learning objects (DLOs).

*Digital Libraries and Repositories of Learning Objects Resources*

All About Learning Objects.
http://www.eduworks.com/LOTT/tutorial/learningobjects.html

*Teacher Training and Curriculum Restructuring*

Comprehensive Educational Restructuring and Technology Infusion Initiative (CERTI2000). This site houses a virtual zoo module design for support a video conferencing instructional program for K-12 education. There is also a lesson plan database and other resources. Although many are still under review, this $2.7 Preparing Tomorrow's Teachers program provided the design for the WEC project described in this paper. The work is ongoing and expanding to include assistive technology learning objects for inclusive learning environments. http://www.uc.edu/certi

*Health Education*

Training Parents and children 6 and over about Asthma Causes, Treatment and Prevention

http://www.asthma.org.uk/flash/movie/go.html

*Social Studies, History, and English*

Repositories of movie speeches, rhetoric, and digital objects can be used to support problem-based learning activities in K-16 education. (E.g. Morgan Freeman's movie, "Lean On Me" speech in 1989. http://www.americanrhetoric.com/MovieSpeeches/moviespeechleanonme4.html

*Engineering, Applied Science and Science Education*

Edinburg Engineering Virtual Library (EEVL). This site provides online learning support objects broken down in to subject areas. Engineering Aerospace & [Defense] Engineering, Bioengineering, Chemical Engineering; Mathematics Algebra, Analysis, Applications, Geometry, Topology, Numerical Analysis, Probability and Computing; Computer Applications, Computer Systems [Organization], and Computing Methodologies

The National University of Singapore has created an Interactive Virtual Learning Environment that requires user log in for faculty or students. The IVLE house digital objects that can be inserted into lectures, lesson plans, or used to enhance learning in other settings.http://www.cit.nus.edu.sg/ideas_back2/LO_new.htm

National Engineering Education System Merlot: MERLOT is a free and open resource designed primarily for faculty and students of higher education. Links to online learning materials are collected here along with annotations such as peer reviews and assignments. Available: http://www.merlot.org

MERLOT – is a peer -reviewed repository that provides multimedia educational resources for learning and online teaching. It houses over 12, 600 digital objects or web-enhanced content that is broken down by seven subject area. Members can also contribute objects for review to be included for others to share. http://www.merlot.org/artifact/BrowseArtifacts.po?catcode=401&browsecat=0

*Instructional Design Models Resources*

Instructional design and theories commonly associated with instructional technology and online learning environments.
http://carbon.cudenver.edu/~mryder/itc_data/idmodels.htmlvirtual lib

Interactive Learning. http://www.cit.nus.edu.sg/ideas_back2/intractv_learng.htm

ISD Knowledge Base / Assimilation Theory. Available: http://www.personal.psu.edu/faculty/s/j/sjm256/portfolio/kbase/Theories&Models/Cognitivism/assimilation.html

Learning Objects and Learning Standards.http://www.learnativity.com/standards.html

Learning Objects Explained. http://www.reusability.org/read/#1