2009

Universal Design for Learning: A Field Experiment Comparing Specific Classroom Actions

Paul Beckman
San Francisco State University, pbeckman@sfsu.edu

Universal Design for Learning: A Field Experiment Comparing Specific Classroom Actions

Paul Beckman
San Francisco State University, College of Business, Information Systems Department
pbeckman@sfsu.edu

ABSTRACT

Universal Design for Learning (UDL) aims to increase accessibility to learning by extending the concepts of Universal Design (UD). UD arose in the field of architecture and suggests that one can increase the accessibility of an architectural feature if certain considerations are made to the design of that feature prior to its construction.

The essence of UDL is to extend accessibility of a learning module to the largest possible group of learners by considering particular design principles prior to construction of that learning module. This paper describes an experiment in which UDL principles were applied in a "treatment" section of a graduate management information systems course but not in an identical "control" section of the same course. The paper methodology section opens with a list of specific classroom actions that support UDL principles, and continues with descriptions of the experiment and data analysis, then a discussion, and finally some conclusions.

Keywords: Universal Design for Learning, Universal Design, management information systems education

INTRODUCTION

Purpose of the Experiment

The purpose of this experiment was to determine if applying components of UDL would result in better learning outcomes when applied in a classroom setting. In particular, the UDL concept of "small-group discussions" was applied in one section of a graduate survey course on information systems and not in another. The goal was to see if this specific action would enhance students' scores on various graded academic measures of assessment.

Universal Design

Universal Design began as a goal of some architects who noticed that, when considered prior to construction of a particular architectural feature, some over-arching design principles could increase the accessibility of that feature to many more users without compromising accessibility to other categories of users. The goal of UD is not to retrofit architectural features to suit the needs of a subset of the user population; consideration of UD principles should occur prior to construction to ensure that the final design is holistically coherent. When applied appropriately, the final design can achieve aesthetic goals, be cost effective, increase accessibility to all user groups, and not impede accessibility to any user groups. While it may be possible to increase accessibility by making changes after an architectural feature has been constructed, when UD principles have been added to those features after-the-fact, the final design often does not achieve the designers aesthetic goals. Also, such post hoc changes typically do not achieve the increases in accessibility than do pre-construction changes. Finally, post-construction changes in design almost always cost more than do pre-construction changes that accomplish the same outcome.

The person generally accepted to have initiated the field of UD is Ron Mace (1990), who worked most of his professional career in promoting the concept of increasing accessibility. From Ron's work at North Carolina State University came the following set of seven UD principles (Connell, Jones, Mace, Mueller, Mullick, Ostroff, Sanford, Steinfeld, Story, and Vanderheiden, 1997) that can be applied to architectural features:

1. Equitable Use: The design is useful and marketable to people with diverse abilities.

2. Flexibility in Use: The design accommodates a wide range of individual preferences and abilities.

3. Simple and Intuitive: Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills, or current concentration effort.

4. Perceptible Information: The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities.

5. Tolerance for Error: The design minimizes hazards and the adverse consequences of accidental or unintended actions.

6. Low Physical Effort: The design can be used efficiently and comfortably and with a minimum of fatigue.

7. Size and Space for Approach and Use: Appropriate size and space is provided for approach, reach, manipulation, and use, regardless of user's body size, posture, or mobility.

The field of UD is now fully accepted as integral to architectural design and its application is common throughout the field. This is so because the pre-emptive application of design principles prior to construction increases the usability of the architectural feature at much lower cost than *post hoc* changes to the feature. One specific and common example of the application of UD is that of the "curb cut". A curb cut is a lowered section of sidewalk, typically at the end of an urban or suburban block that acts as a ramp from the level of the street to the level of the sidewalk. If the value of a curb cut is not anticipated and the sidewalk is constructed without one, accessibility is much reduced for many users. While one typical example of the user of a curb cut is an individual using a wheelchair, curb cuts also increase accessibility for those pushing children in strollers, those moving large items with appliance dollies, the blind, the elderly, and so forth. It is often possible to retrofit a sidewalk with an alternative to a curb cut by placing some type of ramp-like structure protruding from the sidewalk into the street, but such after-the-fact modifications almost always function less effectively, are more costly, and are much less aesthetically pleasing.

Universal Design for Learning

Universal Design for Learning (UDL) extends the basic premises of UD into the realm of education. This means that those educators who wish to maximize the usability of their learning components by increasing accessibility should try to make those changes prior to creating the learning component. Of course, the specific approaches used in UD will differ from those that are appropriate for UDL, but the underlying goals will be the same: increased/maximized accessibility for the widest possible range of users. In the field of UDL, the size of the learning component can vary from a single homework assignment or class discussion to an entire curriculum or degree program. If the application of UDL concepts is appropriate, the final result will be similar to the successful application of UD concepts: more effective and/or more efficient operation by all users.

Very specific actions are needed when an educator gets to the point of applying UDL to their particular selected learning module. However, the first set of "highest order" principles of UDL, at least as applied to undergraduate education, were compiled by Chickering and Gamson (1987), wherein they listed the following goals for a UDL action:

1. Encourages contact between students and faculty.

2. Develops reciprocity and cooperation among students.

3. Encourages active learning.

4. Gives prompt feedback.

5. Emphasizes time on task.

6. Communicates high expectations.

7. Respects diverse talents and ways of learning.

Numerous other academicians and organizations have also contributed to the movement of UDL since that time. CAST (the Center for Applied Special Technology), for example, was founded (CAST, 1984) with a primary purpose of the "development of innovative, technology-based educational resources and strategies". CAST has been a primary promoter of not only applying the concepts of UDL but also of influencing industry and governmental policies.

One academic institution that has recently become involved in investigating UDL is the Sonoma State University (SSU) branch of the CSU (California State University) system. SSU won a $1,000,000 federal grant, called EnACT, to support disabled students in the CSU system in completing their post-secondary goals. One of the earliest achievements within the EnACT grant was to assemble a set of four high-level UDL principles broken down into 14 UDL elements (Ayala, 2005) that could be applied in a classroom. Those four principles and their related components are:

General

1. A statement or information is contained in my course syllabus that specifies campus-based student support services, including disability support services.

2. I provide a comprehensive syllabus that clearly specifies all course requirements, course expectations and due dates.

3. I offer multiple forms of contact information so students have varied ways to contact me with questions or concerns.

Representation

4. I utilize multiple methods of expressing general course content utilizing different modes (visual, graphic, verbal, auditory, etc.) so students have varied ways to access the course content.

5. I provide multiple ways of clearly identifying and explaining essential course concepts (lecture with guided notes, etc.).

6. I ensure accessibility in all course content and materials (accessible websites, captioned videos, e-textbooks, etc.).

7. I provide examples and/or illustrations of all major course assignments or activities.

Engagement

8. I offer varied instructional methods to involve students in the learning process throughout the semester (lecture, small group work, online assignments, class discussion, etc.).

9. I encourage natural support systems (study buddy, partner work, study groups, etc.) in and outside of class.

10. I provide alternatives for students on how they can participate or complete all major course assignments or activities.

Expression

11. I offer clear and specific feedback on assignments and encourage re-submission of assignments as appropriate.

12. I allow students to demonstrate their knowledge of subject matter through a variety of means (oral presentation, written report etc.).

13. I encourage the use of assistive, adaptive or other technologies to ensure that students can accurately express what they know.

14. I provide clear guidelines and/or evaluation rubrics for all major course assignments or activities.

The EnACT grant required expansion to a total of eight other campuses by the end of the 3-year grant period. One of the branches added in the second year of the grant was SFSU (San Francisco State University) where the experiment described in this paper was carried out. As one requirement of being a participant in the EnACT grant, SFSU created a Faculty Learning Committee (FLC) wherein those faculty members who were interested in increasing the accessibility of their teaching would gather once each month to share their experiences. SFSU also created text and video "case stories" about individual faculty member's attempts to implement UDL concepts in their classrooms and how successful were those attempts. The experiment described below was a result of SFSU's inclusion in the EnACT grant, and documents the reasoning, investigation, implementation, and analysis of applying some very specific UDL concepts in a graduate survey course in MIS (Management Information Systems).

METHODOLOGY

Before being able to apply UDL concepts in any classroom, there must be a set of very specific actions from which to choose. Much research has been done in applying UDL concepts in classrooms, but most of that research is focused on K-12 education, education for students with special needs, or is at a very high level and does not provide detailed action plans. In essence, there currently exists no single source of these actions to apply in post-secondary education, so a literature search was executed to derive such a list.

After examining numerous research articles pertaining to the application of UDL concepts in classrooms (Adams, 2005; Bodine, 2005; Bowes, 2003; Burgstahler, 2002; Cunningham, 2003; Czaja, 2005; Gordon, 2005; Lewis, 2005; Pieper, 2005; Roh and So, 2003; Rose, 2005; Savidis and Stephanidis, 2005), a list was compiled that contained many very specific actions that could be implemented in a classroom. The compiled list is not intended to be fully complete and the items on it came from such diverse sources that some items are not independent of others. However, the primary value of the list is that it contained actions that could be implemented very quickly and that would have a direct impact on increasing the accessibility of learning in the classroom. A few of the actions make sense only for some academic disciplines or levels of instruction, but most could be adopted in almost any classroom. Also, some of the actions have been applied or in use for many years; they only appear on the list because they were extracted via the literature search. The complete list of concrete UDL actions, in alphabetic order is:

"Alt" tags for images
Alternative access to teleconferences and videoconferences
Appropriate use of color
Audio output
Avoid page element flicker at 2-55 Hz: seizures
Bulletin boards
Captioning of video
Case studies
Choice in appearance of content
Choice in content
Choice in level of support
Choice in method of response
Choice in speed and distractors
Choice in type of support
Community service
Consistent web page layout
Contact via email
Contact via listserv
Contact via online forums
Email distribution lists
Face students when talking
Flexible images
Flexible-use furniture
Games
Hands-on class demonstrations
Hyperlinks to related material
Multiple forms of distribution of course materials
Nearby restrooms/telephones/parking
Note-taking by several students posted for all students
Notes: "blanks" in notes: students fill in from class discussion
Notes: posted online prior to class
Possibility of one-on-one interaction with students
Read aloud and describe text
Real-time chat
Small group discussions
Speak clearly
Supply visual outlines
Text of printed materials available online
Text that is compatible with speech generators
Text that has hyperlinks
Text with accompanying background information
Text with flexible font sizes
Transcription
Uncluttered web pages
Use HTML validators
Usenet discussion groups
Video
Virtual reality
Wheelchair accessible

The next major step in the experiment was to select one specific UDL action to apply and investigate in one section of a multi-section course. Several specific actions were already in place, for example, "consistent web page layout", "contact via email", "multiple forms of distribution of course materials" "notes: posted online prior to class", and "wheelchair accessible", so these were ignored. Also, the specific UDL action to be chosen was intended to have the greatest anticipated impact on learning, so some actions were ignored, such as "alternative access to teleconferences and videoconferences" (no teleconferences or videoconferences were used in the course), "flexible-use furniture" (the instructor had no control over this), and "virtual reality" (no funding was available for this action). One particular goal of the experiment was to determine if a particular UDL concept impacted a particular form of learning. Therefore, graded material for the class was to be examined and analyzed after the semester to see if the treatment section performed differently than the control section in any particular type of graded assessment.

In this graduate information systems survey course, the graded assessments of learning were comprised of: one class participation score; five homework scores (four homework assignments related to software use and proficiency and one homework assignment related to the semester project); one semester project score (creating a database to store the data for part of some organization); and three independent non-cumulative exam scores. Each of the three exams had the same 3-page format: page #1 of the exam was comprised of multiple choice/fill in the blank questions; page #2 was comprised of essay questions requiring students to apply information technology concepts to specific business situations; and page #3 was comprised of questions about software use. For the purposes of the research experiment, student scores' for each of the exam pages was stored separately. Due to a software malfunction, the scores for individual pages of the first exam were lost

although the total score for the first exam was not lost. After the end of the semester, each of the graded assessments would be statistically analyzed to determine if students in the treatment section scored differently than students in the control section. This analysis would include comparisons of each individual page of the exam, since each exam page assessed a different method of expressing knowledge of information systems. (The university's Internal Review Board accepted the protocol for data collection and analysis since the experiment used human subjects. The student subjects were not told about the experiment until the end of the semester, at which point they were asked if their course scores could be used anonymously in the experiment.)

Based on the constraints described above, the specific UDL action chosen to be applied in the treatment section was "small-group discussions". Prior to this project, small-group discussions were not part of the course; all course topics were taught in a "traditional" lecture format. Therefore, at some point during a class session, the "normal" class process would be stopped and the group of 30 or so students in the class would be divided into smaller groups of 5-8 to talk about the information systems topic at hand. The groups were tasked with answering a number of questions about some information systems topic. After working in these groups for 10-15 minutes, the small groups would re-convene as the full class to discuss what each group had resolved. The instructor would note what each group had compiled, post those comments directly back to the class lecture at that point in time, then re-post the notes back on-line later so that all students could see the results obtained by each small group (and make corrections to those inputs if necessary).

The next step in the project was to determine the most appropriate points in the course in which to apply each this specific UDL action in the treatment section. Such points will, of course, be completely dependent on the course under consideration and will be chosen best by an instructor who has significant experience teaching that course. The graduate survey course in MIS under consideration had been taught by the instructor for several years, so that instructor was given control over this set of project decisions. The "treatment group" section of the course in which UDL actions were to be taken met for 150 minutes once per week in the evening of the fall semester. There were 31 students in that section; all were enrolled in the university's College of Business. The "control group" section of the course met for two 75 minute afternoon sessions per week. It contained 35 students; 31 of them were enrolled in the university's College of Business.

The decision about where to inject small-group discussions is very dependent on course content and so serious consideration was made as to which topics were most appropriate for such discussions. First, since the large class would be divided into 4-5 smaller groups, an MIS topic that was comprised of 4-5 elements would best fit this characteristic of the small group discussions. Second, since one goal of education is to integrate various concepts, an MIS topic that contained elements that could or should be integrated would better fit this characteristic of the smaller group discussions. Third, the course used significant amounts of information technology (course management system, notes posted on-line in multiple formats prior to class sessions, use of presentation software to guide lectures, computer lab sessions, and semester project using software), so topics that could use some or most of that technology would allow a deeper investigation into the use of information technology to support accessibility.

Given these considerations, the instructor chose the following five MIS topic areas for which to task each group in small-group discussions:

1) determine how IS could help a firm using one of Michael Porter's (1980) five competitive strategies

2) determine which type of user interface would be most appropriate for each of five operating system functions

3) describe each of Marshall McLuhan's five elements of communication for specific communication examples

4) describe what data are generated for one of nine e-commerce processes

5) describe what data are passed on to the next stage for each stage in the Systems Development Lifecycle

Data would be gathered in both a qualitative and quantitative manner. Qualitative data would be gathered by the instructor about both the logistical impact that the small-group discussions had on the functioning of the class and about the general feelings students had in both sections. Quantitative data would be gathered by the instructor about the graded academic performance of every student in both sections. Both of these types of data would be compared after the end of the academic term to determine if there was a differential impact on assessed learning of using small-group discussions.

DATA ANALYSIS AND RESULTS

The application of the specific UDL action "small-group discussions" was fairly straightforward to apply to the treatment section of the course. Prior to the class meeting where the small-group discussion would occur, the instructor determined where during the class session the small groups would form, and added several extra slides to the lecture presentation. These

slides indicated that the class would be breaking into small groups and what the small groups should try to accomplish. A few more slides described in greater detail the task that each group was to perform. It quickly became apparent that handouts describing the small-group tasks would be useful so that each group would be able to have on hand the preparatory material (such as the list of Marshall McLuhan's 5 elements of communication or the steps in the SDLC). Since it was useful to have one slide describing each group's task, a separate set of handouts was created for each group. Otherwise, the instructor had to keep switching between the slides showing each different group's tasks and the information systems concept to be applied to the task.

Some topics were more appropriate than others in regard to using information technology directly in the topic discussions. For example, in the task where students chose a user-interface type for particular operating system tasks, it was possible, using Microsoft Windows, to demonstrate directly a command-driven interface (by using the "run" command to open a command window), a GUI (using Windows in mouse-driven mode), and a menu-driven system (using Windows in key-driven mode). It was also possible in this particular topic to show students examples of different operating system functions such as security (running the PC's security software), task management and performance monitoring (opening Window's Task Manager), and file management (using Window's Explorer).

Qualitative Analysis

At a qualitative level, there were several outcomes of the small-group discussions. Of primary importance, students were engaged in a manner other than instructor-driven lecture, as is described in the UDL concept of "engagement". UDL element #8 ("I offer varied instructional methods to involve students in the learning process throughout the semester") suggests that accessibility to learning will increase when the instructor presents the material to be learned in more than one "mode". The small groups allowed students whose learning style is best supported by group discussions to attempt to learn that particular information systems topic in a manner other than a lecture format.

A secondary impact on the class was that the small-group discussions broke up the constancy of the class period. No attempt was made to have the small-group discussions at any specific point in time during the class session; they occurred when each particular topic was arrived at. During and after the small-group discussions, students were much more animated than during the middle of a lengthy period of class lecture. There was also far more voluntary discussion during the small-group meetings. During the standard lecture portion of the class session, typically 5-7 students would volunteer responses to questions posed to the class. During the small-group discussions, however, almost everyone in the class was seen to participate in their group's dialogue. This might be expected, as many people are more likely to participate in a conversation within a small group than to speak up in the middle of a much larger group. This is another advantage of multiple forms of engagement in the learning material: those students who are, for whatever reason, more hesitant to speak by themselves in front of the entire class are more likely to speak in a small group of their peers. It also appeared that once the discussion got going in one of the small groups, that low level of "chatter" induced the other groups to start their discussions.

A third important qualitative impact on the students was that they seemed to appreciate that their small-group work was recognized during the re-convening of the large group and the subsequent re-posting of class notes with their group's contribution added. At the end of each small-group discussion period, the groups were assembled as the full class and each group was polled as to the result of their discussion. Each group's result was entered into the presentation slides immediately at that point, so the other groups could see all groups' contributions. Those updated notes were then re-posted back on-line so that each student could re-examine what happened during that part of the class. This allowed students to pay more attention during class, knowing that the results would be available later on-line. This also allowed each student to check on the veracity of their group's results as they were posted in public for all students in the class to see.

These qualitative results suggest that adding the UDL concept of "small-group discussions" should lead to greater satisfaction in the learning environment through the variety introduced in the methods of "presentation" of knowledge. That is, the knowledge that students were expected to absorb was presented in more than one form, thus increasing the likelihood that more students absorbed that knowledge due to the variety of learning styles across different students.

Quantitative Analysis

Two quantitative analyses were performed: one on a standard "course and instructor evaluation" survey given throughout the College of Business and one on the quantitative results of all graded material from the semester.

The course/instructor evaluation given to both sections was created by San Francisco State University and appended to by the College of Business. It is given to all students in College of Business sections where courses/instructors are evaluated by students (not all College of Business sections are evaluated by students). The seven statements on the survey all had

response criteria, unless otherwise noted, of numeric values ranging from "1" (Strongly Agree) to "5" (Strongly Disagree). The seven statements were:

1. The instructor defined the course objectives, learning activities, requirements and grading policies clearly in the syllabus.
2. The course was organized in a way that helped my learning.
3. The instructor created experiences that stimulated my learning.
4. The instructor provided helpful and timely feedback on my performance and progress throughout the semester.
5. The instructor was open to a variety of points of view.
6. When I consider the contribution to my learning, this instructor's teaching was: 1 (Highly Effective) – 5 (Ineffective)
7. My overall evaluation of this instructor is:1 (Excellent); 2 (Good); 3 (Average); 4 (Substandard); 5 (Poor)

The only survey statement whose score was statistically different between the treatment section and the control section was statement #5: "The instructor was open to a variety of points of view". Students in the treatment section were more likely (t-test value: -1.87; df: 58; critical value: 1.671) to have responded that their instructor was "more open to a variety of points of view". Note that lower scores on the survey statements represented a "higher quality" instructor and/or course.

The second quantitative analysis examined the difference in scores between the treatment and control sections for the 10 items of graded material (1 class participation score, 5 homework scores, 1 project score, and 3 exam scores). As mentioned above, the score for each of the three exam pages (with their different response methods) was tracked separately, but data were only available for the second two exams.

The only scores for the 10 items of graded material that showed a statistically significant difference between the treatment and control sections were: page two of exam #2, page two of exam #3, and total score for exam #3. The t-test values for these significantly different scores are shown in Table 1 below.

Independent means t-test	
DF=	**58.00**
t(critical)	**1.671**
Item	**t-test value**
Exam 3 page2	2.54
Exam3 total	2.27
Exam2 page2	2.18

Table 1. Graded material scores: treatment vs. control

These quantitative results indicate that adding the UDL concept of "small-group discussions" led to greater learning through the different ways that the knowledge was presented in the classroom. That is, similar to the qualitative outcomes described above, the knowledge that students were expected to absorb was presented in more than one form, thus increasing the likelihood that more students will absorb that knowledge due to the variety of learning styles across different students. Also, by using more than one method of presenting knowledge, students in the treatment section apparently felt that the instructor was more open to other points of view. One possible reason for this particular quantitative outcome is that the instruction in the classroom was not purely uni-directional (from instructor to others) but was multi-directional (from instructor to others AND from student to others) in that it was much easier, in fact it was mandatory that, students give their own thoughts about the topic at hand. This may have given students the feeling that the instructor was open to what students thought about the MIS topics.

DISCUSSION

The qualitative results suggest that students found some value in the small-group discussions. Also, having the academic material presented in more than one format (small-group discussions as well as lecture) supports the UDL principle of offering multiple forms of presenting course material to support the possible multiple learning styles of different students. Small-group discussions also broke up the uniformity of the class and allowed students a chance to get up and move around. During the small group discussions, those students who might be afraid to speak in front of the whole class were given the opportunity to voice their opinion in a more "safe" small group of their peers. Finally, by reconvening as a larger full class at the end of the small-group discussions, each individual, through their smaller group, was able to see their own ideas presented to the entire class. The instructor also re-posted the results of the small-group discussions back to the on-line notes, giving students more ownership of their own and their group's contribution to the class. In the overall process of participating in small-group discussions, it seems that students were able to more deeply delve into the IS topic at hand, thus better preparing them for discussing those IS topics in a deeper manner as was required in answering exam essay questions. That is, the deeper knowledge of IS topics gained in small-group discussions apparently did not help students in answering the exam multiple-choice or fill-in-the-blank questions, as those types of questions require only knowledge to "recognize" or "recall" information and not "apply knowledge".

One reason that the small-group discussions may not have has as large an effect on measured course materials is that they did comprise a relatively small amount of the overall class session time. Because of the class time required for exams and computer labs, small-group discussions were held in only 5 of 15 class sessions throughout the academic term. (This number has since been expanded to 8 class sessions out of 15 total class sessions.) This very likely limited the overall impact of that treatment effect on the graded assessments. Also, the reason that small-group discussions did not have a major impact on the graded assessment of "class participation" is that the class participation points were assessed based on students leading textbook case discussions and bringing current new items to present to the class. Although these two class participation actions were optional, every student completed both of them. The impact of participating in the small-group discussions may therefore have been secondary to the students desire to earn class participation points.

The quantitative results showed that there was a difference between the learning outcomes of the treatment and the control groups. The quantitative analysis of the survey responses of students who had completed the course showed that those students in the treatment section indicated that they felt the instructor "was open to a variety of points of view" more than did the students in the control section. This apparently is so because the small group discussions in the treatment section must have allowed the students to feel that their (and other) points of view would be heard, more than did the students in the control section that did not have small group discussions.

The quantitative analysis also showed that the students in the treatment section performed better on the graded material in the course that was related to applying their knowledge in an abstract written manner. This differential learning appeared on both the second and third exams. There was not a statistically significant difference between student graded performance on the other two parts of the exam that tested students on multiple choice/fill-in-the-blank questions and questions on use of software. There was also not a statistically significant difference in scores for the other graded material in the course (software-based homework assignments, software-based semester project, and class participation). This implies that the value of the small group discussions appears in learning that is assessed in abstract written outcomes wherein knowledge is applied to a novel situation, rather than in situations where learning is assessed using multiple choice/fill-in-the-blank questions, questions about software use, actual software use, or in level of class participation. For this course, it would not be expected that small group discussions would impact learning of software as none of the small group discussions pertained to software use. It might be expected that class participation scores would be impacted by implementing small group discussions, as the action of participating in a small group discussion might induce students to participate more in class. In this experiment, the quantitative analysis did not show this effect.

CONCLUSIONS

This experiment compared the differences in learning outcomes after applying a principle of Universal Design for Learning in two separate sections of a graduate Management Information Systems course. First, many specific UDL actions were extracted from the literature and enumerated. Second, several actions were selected from that list based on their expected impact on learning and cost and ease of implementation and one action, "small-group discussions", was implemented in the "treatment" section and not implemented in the "control" section. Course topics were then selected where those UDL actions and information technology could be applied most appropriately. Finally, the two sections were taught and data gathered from the graded material for each of the sections and both qualitative and quantitative analyses were made to assess the impact on learning of applying the small group discussion concept.

The qualitative difference between the two sections suggests that, on the surface, students become more engaged when they are presented with multiple forms of course content. If care is taken in selecting those multiple forms of presentation, students can be induced to interact more than they would in a traditional classroom setting. Also, the action of re-posting notes with added content from small-group discussions is really only available in a situation where information technology is used to maintain course lecture notes. This process gives students more ownership of the course notes as the students themselves have contributed to that content.

A statistical analysis of the assessed learning outcomes of the students showed that students in the treatment section:

1. thought "the instructor was open to a variety of points of view" more than did students in the control section.
2. performed better on "essay-type" exam questions than did students in the control section.
3. performed the same as students in the control section on: multiple-choice/fill-in-the-blank exam questions, written software exam questions, actual software use (in a semester project), and class participation.

On a minor note related to the logistics of the experiment as a whole, the most time-consuming stage of the research was compiling the list of specific UDL actions for a classroom. There is apparently no existing source of very specific "accessibility-increasing" actions that an instructor can take in their classroom. There are numerous sources available that suggest or examine a very small number of such actions, but those sources are typically focused on one case or one technology or one educational arena. Once that list was compiled, it was a much more simple matter to merely select items from the list and consider them for suitability in the learning situation that existed for this experiment.

UDL is somewhat new, but it is a field that is growing rapidly. It is important for educators in all academic areas to understand the fundamental principles of it to best increase the accessibility of their learning modules. Information technology is likely to be a fundamental tool for supporting UDL applications, as IS/IT can perform most of the processes needed to implement any of the 14 UDL elements as are enumerated in the EnACT grant. This experiment was an effort to research, examine, apply, and compare very specific UDL actions in a graduate course and present the results to other educators. Of course, much work still needs to be done, but the value of applying UDL principles will be, for many individuals, increased access to learning.

REFERENCES

1. Adams, R. (2005) An Overview of Cognitive Skills and Impairments for Cognitive Work, *Accessibility and Computing*, September, 2005.
2. Ayala, E. (2008) Ensuring Access Through Collaboration and Technology, 2005, a Federal Grant, Sonoma State University website, found at: http://enact.sonoma.edu/, accessed February 1, 2008.
3. Bodine, C. (2005) Cognitive Impairments, Information Technology Systems and the Workplace, *Accessibility and Computing*, September, 2005.
4. Bowes, F. (2003) The Columbia Guide to Digital Publishing, Columbia University Press, New York, NY.
5. Burgstahler, S. (2002) Distance Learning: Universal Design, Universal Access, *AACE Journal*. 10, 1, pp. 32-61. Norfolk, VA: AACE.
6. CAST (1984) Transforming Education Through Universal Design for Learning, found on-line at: http://www.cast.org/, accessed February 1, 2008.
7. Chickering, A., and Gamson, Z. (1987) Seven Principles for Good Practice in Undergraduate Education, *The American Association for Higher Education Bulletin*, March, 1987.
8. Connell, B., Jones, M., Mace, R., Mueller, J., Mullick, A., Ostroff, E., Sanford, J., Steinfeld, E., Story, M., and Vanderheiden, G. (1997) The Principles of Universal Design, North Carolina State University, Center for Universal Design, College of Design Poster, 1997, found online at: http://www.design.ncsu.edu/cud/pubs_p/docs/poster.pdf; accessed February 1, 2008.
9. Cunningham, A. (2003) Supporting Student-Centered Teaching and Learning: Technology in Wake Forest University Education Programs, *Contemporary Issues in Technology and Teacher Education*, 3, 1.
10. Czaja, S. (2005) The Impact of Aging on Access to Technology, *Accessibility and Computing*, September, 2005.
11. Gordon, W. (2005) The Interface Between Cognitive Impairments and Access to Information Technology, *Accessibility and Computing*, September, 2005.

12. Lewis, C. (2005) HCI for People with Cognitive Disabilities, *Accessibility and Computing*, September, 2005.
13. Mace, R. (1990) Definitions: Accessible, Adaptable, and Universal Design, *FACTsheet*, Center for Universal Design, College of Design, North Carolina State University.
14. Pieper, M. (2005) Digital Divide and Learning Disabilities – Counteracting Educational Exclusion in Information Society, *Accessibility and Computing*, September, 2005.
15. Porter, M. (1980) Competitive Strategy, The Free Press, New York, NY.
16. Roh, S-Z., and So, H-J. (2003) Designing Accessible Web-Based Instruction for All Learners*, Proceedings of the 19th Annual Conference on Distance Teaching and Learning*, August, 2003, Madison, WI.
17. Rose, D. (2005) Cognition and Learning: Meeting the Challenge of Individual Differences, *Accessibility and Computing*, September, 2005.
18. Savidis, A., and Stephanidis, C. (2005) Developing Inclusive e-Learning and e-Entertainment to Effectively Accommodate Learning Difficulties, *Accessibility and Computing*, September, 2005.