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# Differences in Factors Affecting Academic Success for Disabled Individuals in Technology-Mediated Learning Environments

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# DIFFERENCES IN FACTORS AFFECTING ACADEMIC SUCCESS FOR DISABLED INDIVIDUALS IN TECHNOLOGY-MEDIATED LEARNING ENVIRONMENTS

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## Abstract

*Extant literature does not show the relationship between design attributes of Technology-mediated Learning (TML) environments or Course Management Systems (CMS) and behavioral attributes and their impact on academic success of students with disabilities. In addition, existing research does not consider the perceptions of disabled users regarding accessibility and its impact on the effectiveness of TML. We examine antecedents of academic success for university students with disabilities working in TML environments and in particular for those with visual impairments. We also investigate if these factors are more influential for visually impaired students in comparison to students with other disabilities. We examine the impact of three design attributes - accessibility, usability, and media richness of a CMS, and a behavioral attribute - learning motivation – on the learning outcome of individuals with disabilities. Based on our findings, we hope that higher education institutions will deploy accessible and usable CMS to positively impact the academic success of students with disabilities, particularly those with visual impairments.*

**Keywords:** Accessibility; Technology-mediated Learning; Usability; Disability; Course Management System; Assistive Technology.

## Introduction

Higher education today increasingly incorporates technology-mediated learning (TML) where information and communications technology facilitate education (Alavi and Gallupe, 2003). TML is employed in two environments: traditional classrooms and distributed learning (Alavi & Leidner, 2001). These are delivered via platforms known as course management systems (CMS). TML has several benefits over traditional methods. One important benefit lies in its potential to

provide equal access to learning. Research shows that TML benefits people with disabilities more than those without disabilities (Anderson-Inman et al, 1999; Hasselbring and Glaser, 2000). However, the benefits of TML for disabled students in higher education are yet to be realized (NCDSSA, 2000). A major reason for this has been the inaccessibility of technology itself (Rowland et al, 2004; Burgstahler, 2003; NCDSSA, 2000).

New technologies used in higher education, particularly CMS, pose accessibility barriers to students with disabilities (Hitchcock and Stahl, 2003; Burgstahler, 2004). Among the disabled population, accessibility issues related to technology are considerably more for visually impaired students (Erin, 2006). Federal legislations mandate that institutions provide equal learning opportunities to individuals with disabilities. Noteworthy among these legislations are the American's with Disabilities Act (ADA) of 1990, and Section 508 of the Rehabilitation Act of 1998. However, these regulations have not resulted in a barrier-free learning environment for disabled individuals (Fipps, 2006; Green, 2006).

*Accessibility* refers to the attribute of a system that allows individuals with disabilities to use them through non-traditional means (Thatcher et al., 2002). Since course management systems are integral to a TML environment, they must be designed to provide equal access. So, a CMS must be designed to be accessible at the least. However, the complex environments in CMS present numerous accessibility issues for disabled users. For example, finding the right information, navigability and working with multi-media are challenging at best for visually impaired and other disabled people.

*Usability* of a CMS is another design attribute that has an impact on the learning success for a person with disability (Stewart et al., 2005). Usability includes ease of reading, arrangement of information, and layout (Nielsen 1993). Disabled users comprise of a heterogeneous group, including people with visual, hearing, motor, and cognitive impairments. These impairments restrict certain modes of interaction with computers. For example, visually impaired people avoid graphical interfaces, while hearing impaired individuals avoid acoustic information. Therefore, a CMS with high *richness* will be more accommodative (Webster & Hackley, 1997). Here, richness refers to the ability of a CMS to present information in multiple modes, depending on the preference of the disabled user. In addition to the cognitive demands of higher education, individuals with disabilities face additional demands imposed by the challenges of interacting with course management systems and various technology-mediated learning environments. Therefore, such individuals require additional *motivation* and effort in order to achieve academic success (Huang, et al. 2005).

In this study, we examine antecedents of academic success for university students with disabilities, and in particular those with visual impairments. Our focus is on TML environments ubiquitous in higher education today. Specifically, we attempt to answer the following research questions:

- *What factors influence the academic success of students with disabilities, working in TML environments?*
- *Are these factors more influential for visually impaired students in comparison to students with other disabilities?*

We present a model to explain academic success of disabled students working in a TML environment. We propose three design attributes - *accessibility*, *usability*, and *media richness* of a CMS, and a behavioral attribute - *learning motivation* – that positively impact the learning outcome of individuals with disabilities. Extant literature does not show the relationship between design attributes of TML or CMS, with behavioral attributes and their impact on the academic success of students with disabilities. In addition, current research does not consider the perceptions of disabled users regarding accessibility and its impact on the effectiveness of TML in instructional delivery. This study will establish the critical role of accessibility in TML. We hope that higher education institutions will deploy accessible and usable CMS to positively impact the academic success of students with disabilities, particularly those with visual impairments.

## Theoretical Background

The theoretical foundation for this study is based on an extensive literature review on Web accessibility, usability, media choice, motivation, technology-mediated learning, and learning outcomes. The following sections briefly introduce and discuss these concepts and their relevance in this study.

### *Accessibility*

Accessibility is derived from the term “accessible,” which Webster defines as capable of being used, seen, understood or appreciated (<http://209.161.33.50/dictionary/accessibility>). When discussed in the context of the Web, accessibility is the ability of people with disabilities to perceive, understand, navigate, and interact with the Web (<http://www.w3.org/WAI/intro/accessibility.php>). In this study, accessibility is the attribute of a CMS that allows users to understand and fully interact with its contents, with the aid of assistive technologies (Thatcher et al., 2002). According to Section 508 of the Rehabilitation Act (1998), assistive technology is a “device or software that substitutes for or enhances the function of some impaired ability.” Therefore, a critical factor in design for accessibility is design for assistive technology (Englefield et al., 2005). Accessible design should allow for assistive technologies to effectively mediate the interaction between the TML interface and users with disabilities.

Accessible design attempts to enable universal access to interactive systems, regardless of user impairments and preferred client technology (Shneiderman, 2000). Accessible design supports the specific needs of distinct groups challenged by impairments related to vision, hearing, motor skills, and cognitive abilities (Sloan, 2006). A diverse range of challenges must be addressed in design for accessibility. For example, within the vision impaired category, distinct design responses are necessary to support blind users, when compared to design responses for users with limited vision or tunnel vision (Cooper, 2005). In supporting blind users, a key concern is to provide appropriate encoding of content for screen readers. For users with limited or tunnel vision, the emphasis is on a range of techniques including appropriate typography, sensitivity to the diminished context associated with use of a screen magnifier and support for user-defined font sizes. Additional design responses are required to facilitate input by users with other forms of disabilities (Englefield et al., 2005).

Efforts to establish guidelines for Web accessibility include The Web Accessibility Initiative (WAI), ([www.w3.org/WAI/](http://www.w3.org/WAI/)) which is part of the World Wide Web Consortium (W3C). The W3C developed the Web Content Accessibility Guidelines (WCAG) 1.0 in effort to guide the design of interfaces that make web content accessible to people with disabilities. According to the WAI, web content generally refers to the information in a Web page or Web application, including text, images, forms, sounds. The WCAG comprises 3 levels of compliance, A, AA and AAA. Each level imposes a more stringent set of conformance guidelines including different versions of XHTML (Transitional vs Strict) and other techniques that need to be incorporated into the code before accomplishing validation. Online tools, such as the Watchfire WebXACT engine ([webxact.watchfire.com/](http://webxact.watchfire.com/)), automatically run a website through the WCAG guidelines and generate a compliance report. Another source of web accessibility guidance comes from Section 508 of the US Rehabilitation Act. This section is a comprehensive set of rules designed to help web designers make their sites accessible. To comply with accessibility standards, web applications, including CMS, must have the following (Burgstahler, 2004; Rowland et al, 2004):

- XHTML Validation from the W3C for the content of web pages;
- CSS Validation from the W3C for the page layout;
- At least WAI-AA compliance with the WAI's WCAG;

- Compliance with all guidelines from Section 508 of the US Rehabilitation Act;
- Access keys built into the HTML; Semantic Web Markup;
- A high contrast version of the site for individuals with low vision; and
- Alternative media for any multimedia used on the site (video, flash, audio).

Incorporating accessibility early in the design of TML environments is more effective than developing post-implementation solutions that consider accessibility as an add-on to web applications. The literature supports the fundamental role of design accessibility for effective TML environments. In this research, we explore the implications of accessibility in TML environments in an attempt to establish its critical role in the academic success of disabled individuals in higher education.

### ***Usability***

Web site usability has received considerable attention in the human computer interaction (HCI) literature and in Web-specific usability research. It is an engineering approach that identifies a set of principles and common practices in systems design (Nielsen 1993). It includes the facilitation of a user's goal-oriented behavior, consistency, clarity of interaction, ease of reading, arrangement of information, speed, and layout. Appropriate design of user interfaces includes organization, presentation, and interactivity (Shneiderman, 1998). A higher usability implies a system that is easier to use (Bevan et al, 1991). Students can learn better and faster when the CMS is hassle free (Stewart et al. 2004).

The Disability Rights Commission (2003) reports on the importance of Web site usability for people with disabilities. According to this report, "45% of the 585 accessibility and usability problems were not a violation of any WAI-WCAG Checkpoint and could therefore have been present on any WAI-conformant site regardless of rating". This illustrates a limitation of the WAI-WCAG. With interfaces that conform to current standards, disabled users continue to experience usability issues three times more than non-disabled users (Nielsen, 2001). Designing these systems following usability principles will ensure that its web pages are readable; buttons and links are easily identified; navigation is easily understood; structures are easily recognized; and current position is well understood (Stewart et al. 2005; Nielsen, 2001; Shneiderman, 1998). Effective CMS should be usable and not just accessible.

### ***Media Richness***

Richness of Web resources refers to the medium's relative ability to convey messages. Media can be face to face, telephone, documents (Daft and Lengel, 1986), e-mail (Markus 1994), and computer-mediated and video communication (Dennis and Kinney 1998). The richness of a system reflects the variety of ways information is presented and the speed of obtaining information (Dennis and Valacich, 1999). The specific influence of a given medium is often dependent on the task being performed (Daft and Lengel 1986). Finding information that is of high quality within the computer-mediated context is an important element (Hoffman and Novak, 1996; Dickson 2000). In this study, richness refers to the variety of ways in which information is presented by the CMS. A richer CMS has greater reach to users with disabilities. Disabled users are a heterogeneous group with visual, hearing, motor, and cognitive impairments. Each group has different needs with interacting with computers. Problems arise when information presented in a particular mode is not appropriate for the specific disability. Therefore, a CMS should be able to present information in multiple modes (Webster & Hackley, 1997). We investigate the impact of richness of CMS on academic success of disabled individuals in higher education.

### ***Learning Motivation***

Learning motivation influences learning outcome. This is especially true in TML as the learner relies on self motivation in the online education program. Huang et al. (2005) examined the correlations among virtual team learning, learning

motivation, and learning outcome (satisfaction) for an online MBA program. They reported that learning motivation was significantly correlated with learning outcome (Huang, et al. 2005). We investigate the impact of learning motivation on academic success of disabled individuals in TML environments.

### Perceived Learning Success

Chickering and Gamson (1987) identify seven guidelines for effective learning in the university environment. These guidelines are: (a) encourages contact between students and faculty, (b) develops reciprocity and cooperation among students, (c) encourages active learning, (d) gives prompt feedback, (e) emphasizes time on task, (f) communicates high expectations, and (g) respects diverse talents and ways of learning.

A number of studies have examined learning effectiveness in TML environments using student perceptions of their success (Robertson, et al. 2005). Perceived success of learning is a measure of learning outcome (Picciano, 2002). Students need support when concerned or confused, and TML tools like CMS could improve access to faculty (Chickering & Ehrmann, 1996). Study groups, collaborative learning, group problem solving, and discussion of assignments are all methods in which reciprocity and cooperating among students can be improved online (Knipe and Lee 2002). According to Valenta et al. (2001), as CMS encourages synchronous conversations and improves active learning in the university classroom.

### Model and Hypotheses

This study adopts a holistic approach to accessible TML and highlights the importance of accessibility, usability, and media richness of CMS in learning success while recognizing the significance of motivation to learning outcome. The independent constructs - accessibility, usability, media richness, and learning motivation – are hypothesized to influence the dependent construct, perceived success of learning, a measure of learning effectiveness (Picciano, 2002). The proposed model is shown in Figure 1.

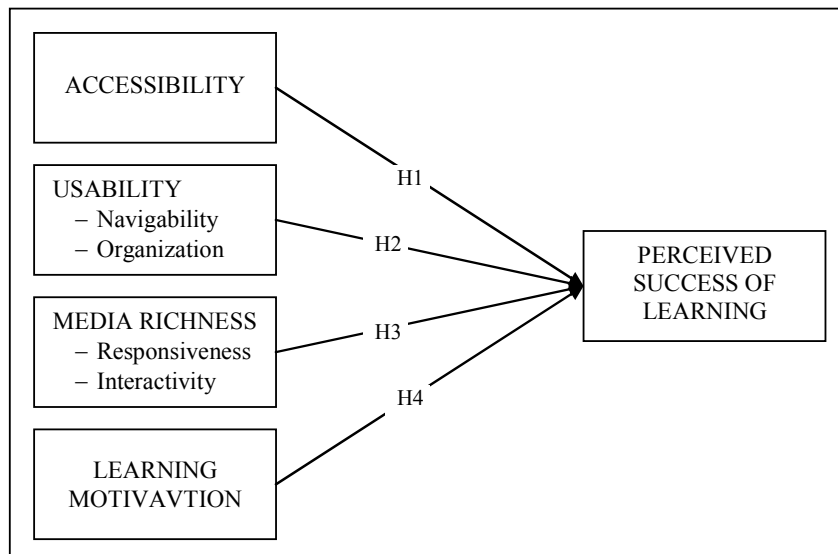


Figure 1: Research Model

Students with disabilities can only use a system if it is designed with accessibility. TML will be successful if the delivery platform is accessible. We propose that accessibility of a CMS positively influences the learning outcomes. Our first hypothesis is:

H1: CMS Accessibility positively influences the perceived learning success of disabled students.

Usability is equally important for using a system. We hypothesize that usability leads to improved learning as stated in our second hypothesis:

H2: CMS Usability positively influences the perceived learning success of disabled students.

Media richness of the CMS will have a positive impact on learning success, leading to our third hypothesis:

H3: CMS Richness positively influences the perceived learning success of disabled students.

Learning motivation reflects the desire to learn despite challenges. Successful learning, under any situation, requires positive motivation from the student. This is particularly important for students with disabilities.

H4: Learning motivation positively influences the perceived learning success of disabled students.

Disabilities can be due to impairments of vision, hearing, mobility or cognition. Several problems related to technology access and use are known to be experienced by the blind and visually impaired (Erin, 2006). Any attempt to make systems accessible will help this group of users more than other disabled users. Thus, we wanted to investigate if there were differences in the independent factors between visually impaired students vs. other disabilities. Hence, the following hypotheses:

H5: The influence of CMS accessibility on the perceived learning success is greater for visually impaired students than for students with other disabilities.

H6: The influence of CMS usability on the perceived learning success is greater for visually impaired students than for students with other disabilities.

H7: The influence of CMS richness on the perceived learning success is greater for visually impaired students than for students with other disabilities.

H8: The influence of motivation on the perceived learning success is greater for visually impaired students than for students with other disabilities.

## Methodology

To test the proposed model, we adopted a positivist approach using a survey method. We developed an instrument based on items validated by previous studies discussed in the sections below.

### *Study Settings and Subjects*

Subjects of this study were individuals with disabilities who used a computer exclusively with an assistive technology, (e.g. screen readers for visually impaired, close-captioning for hearing impaired, and Kurzweil for cognitively impaired). They were enrolled in a course partly or fully delivered via CMS. These individuals were approached through the Office of Disability Services. Data for the study was collected from 32 students with various disabilities, including 11 visually impaired, 6 hearing impaired, and 15 cognitively impaired.

For accessibility, items from Brunet et al. (2005) was used and modified to capture the perspective of visually impaired users on accessibility and learning success. For usability, media richness, and perceived success, Palmer’s (2002) study on users’ perceptions of e-commerce websites was found germane. We used Huang, et al. (2005) survey items for learning motivation. The consolidated instrument comprised of 22 items for various constructs. Five items were used to measure CMS accessibility including ability to: upload and download content; participate in discussion and communication features; participate in chat sessions; keep track of progress in course, and overall accessibility. CMS usability was measured using five items as well: navigation, easy to use, sequence of obtaining information, how predictable succeeding links were; and how easy it was to learn based on layout. The six items to measure CMS richness were: provision of frequently asked questions (2 questions), feedback features (2 questions), and how customizable (2 questions). Learning motivation was measure using three items: interest of students in learning through the CMS, if they strived to perform better using CMS, and if they attempted to do their best in the course using CMS. Finally, perceived success in learning was measured using three items: if they performed better in class discussions using CMS, if they performed better in exams taken over CMS, and if the learnt better via CMS. The next section presents the analysis of the results.

## Data Analysis

We used SPSS 13.0 for statistical analysis. Table 1 below shows the covariance and reliability test results. All Cronbach alphas were above the acceptable value of .70 (Nunnally, 1967).

**Table 1: Covariance and Internal Reliability**

Covariance Matrix Demonstrating Internal Reliability						
	Accessibility	Usability	Media Richness	Learning Motivation	Perceived Success	Cronbach’s Alpha
Accessibility	1.0					0.915
Usability	0.2693	1.0				0.879
Media Richness	0.5149	0.3148	1.0			0.906
Learning Motivation	0.4430	0.4432	0.6333	1.0		0.810
Perceived Success	0.8329	0.6455	0.7927	0.6551	1.0	0.833

For convergent and discriminant validity, factor analysis was performed in addition to scale reliability. Factor loading (Table 2) of most items was satisfactory (>0.7). Factors A1 through A5 correspond to accessibility, U1 through U6 correspond to usability, MR1 through MR5 correspond to media richness, LM1 through LM3 correspond to learning motivation, and PS1 through PS3 correspond to perceived success of learning.



**Table 2: Factor Loadings**

	Factor				
	1	2	3	4	5
A1		0.873			
A2		0.859			
A3		0.760			
A4		0.788			
A5		0.810			
MR1	0.703				
MR2	0.726				
MR3	0.685				
MR4	0.843				
MR5	0.791				
MR6	0.785				

	Factor				
	1	2	3	4	5
U1			0.811		
U2			0.748		
U3			0.675		
U4			0.844		
U5			0.843		
LM1					0.749
LM2					0.720
LM3					0.694
PS1				0.809	
PS2				0.603	
PS3				0.661	

Data was subjected to multiple regression (Table 3), using mean of each construct, indicating significant regression model ( $F=7.220$ ,  $p=0.000$ ) and adjusted  $R^2 = 0.445$ . Results indicate support for H1 and H2 and lack of support for H3 and H4 (Table 4).

**Table 3: Regression Analysis Results**

Analysis of Variance					
	SS	DF	Means	F-Ratio	P-value
Regression	9.044	4	2.261	7.220	0.000
Residual	8.456	27	0.313		
Total	17.50	31			

**Table 4: Results of Hypotheses Testing**

Hypotheses	Coefficient (p-value)	Supported
H1: CMS Accessibility positively influences the perceived learning success of disabled students.	0.392 (0.020)	YES
H2: CMS Usability positively influences the perceived learning success of disabled students.	0.328 (0.037)	YES
H3: CMS Richness positively influences the perceived learning success of disabled students.	0.260 (0.169)	NO
H4: Learning motivation positively influences the perceived learning success of disabled students.	0.044 (0.815)	NO

**Table 5. Differences between visually impaired and students other disabilities**

Hypotheses	Coefficient (Cohen's D)	Supported
H5: The influence of CMS accessibility on the perceived learning success is greater for visually impaired students than for students with other disabilities.	0.70	Yes
H6: The influence of CMS usability on the perceived learning success is greater for visually impaired students than for students with other disabilities.	0.64	Yes
H7: The influence of CMS richness on the perceived learning success is greater for visually impaired students than for students with other disabilities.	0.32	No
H8: The influence of motivation on the perceived learning success is greater for visually impaired students than for students with other disabilities.	0.26	No

Table 5 shows the results of test for group differences. A one-tailed, two-sample T-test for two independent groups of unequal size was performed on the data. Group I comprised 11 subjects with vision related disabilities, while group II comprised disabilities related to hearing and learning. The Cohen's D statistic helps to establish the practical significance of the T-statistics. A Cohen's D value between 0.30 and 0.50 represents a low to moderate effect, while anything above 0.50 represents a high effect.

## Discussion

As is evident from Table 4, we found strong support for hypotheses H1 and H2 that the accessibility and usability of the course management system influences the learning outcome of students with disabilities. In other words, a CMS that is more accessible and usable will lead to better academic success for students with disabilities. However, hypotheses H3 and H4, which pertain to the influence of CMS richness and motivation, could not be supported. In other words, these factors were not found to influence learning outcome of disabled students. A possible explanation for this may be due to the lack of variability related to these variables.

As is clear from Table 5, hypotheses H5 and H6, i.e. CMS accessibility and usability influence learning outcome of visually impaired students more than students with other disabilities. This result may be interpreted in the following way. Since vision-related disabilities pose the greatest level of difficulties while using the Web (Rowland et al. 2004), accessibility and usability will have greater impact on the ability of such individuals to use a system for the intended purpose. In other words, the CMS with greater accessibility and usability will lead to better learning outcomes for visually impaired students as compared to students with other disabilities. However, the data analysis could not support H7 and H8, that richness and motivation influence the learning outcome of visually impaired students more than that for other disabled students.

Following from the above results, it is evident that challenges experienced by visually impaired students are the greatest, and may lead to their marginalization. We believe it is imperative that CMS be made accessible and usable to achieve better learning outcomes for disabled students, in particular visually impaired and blind students.

## Limitations and Future Research

This study represents a preliminary investigation into the factors that influence learning success for disabled students in a TML environment. This study is limited in two aspects: sample size and choice of CMS. The sample size of thirty-two is small for a full-scale study. However, considering the novelty of this study in terms of surveying disabled students, coupled with the fact that not all students with disabilities use technology, it is very difficult to get a large sample size of students with these unique characteristics. A second limitation is the lack of variability in CMS richness. In future research, we will investigate the effects of media richness on learning outcomes across different platforms. We are currently developing a large-scale survey that involves students with disability from multiple universities across the U.S. This will also help include students with other disabilities not considered in this study.

Another avenue for research is to do a comparative examination of various CMSs for accessibility, usability, and media richness. Based on the findings, taxonomy for good CMS design, pertaining to the three constructs can be developed. This can serve as checkpoints for institutions looking at CMS adoption. Another study involves an examination of the effect of learning motivation in e-learning at different levels of education, controlling for other factors. This would shed light on the impact of motivation on learning success of students with disability. A study involving the development of a framework for academic success that considers different forms of disabilities as well as learning styles would be beneficial for academic institutions.

## Conclusion

Technology-mediated learning, by its very nature, offers a range of advantages over traditional methods. When TML is delivered through course management systems that are accessible and usable, it offers a level learning field, irrespective of physical or sensory abilities. In spite of all regulations and guidelines on accessibility and usability, equal access is still illusive. Although access issues in TML arise from two sources – course materials and medium of delivery – the medium of delivery can be standardized. Based on this study, we believe that realizing the criticality of accessibility, higher education institutions will deploy accessible and usable CMS to positively impact the academic success of students with disabilities, particularly those with visual impairments. We hope this will encourage students with disabilities to pursue higher education, facilitated by accessible and effective TML that positively impacts their learning motivation and academic success. As a starting point, colleges and universities must ensure that the CMS being deployed are accessible, usable, and rich. This will lead to effective learning environments for students with disabilities, particularly visually impaired, that are conducive to their academic success.

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