Asynchronous Online Access as an Accommodation on Students with Learning Disabilities and/or Attention-Deficit Hyperactivity Disorders in Postsecondary STEM Courses

Laura Graves
Paul A. Asunda
Stacey J. Plant
Chester Goad
Tennessee Technological University

Abstract

The purpose of this study was to investigate whether asynchronous online access of course recordings was beneficial to students with learning disabilities (LD) and/or Attention Deficit/Hyperactivity Disorder (ADHD) enrolled in science, technology, engineering, and mathematics (STEM) courses. Data were collected through semi-structured interviews lasting 40 minutes. A total of 11 student participants with LD and/or ADHD were interviewed. Student participants were enrolled in math, biology, and chemistry courses that utilized asynchronous online access of digital recordings. Interview data were individually analyzed and compared through a cross-case analysis. Students reported that the use of asynchronous online access enhanced their learning experiences according to six themes: clarity, organization, asynchronous access, convenience, achievement, and disability coping mechanism.

Keywords: STEM, access, disabilities, universal design, web-based

Graduating with a degree from a postsecondary institution has become an achievable goal for many students. However, for some students, especially those with learning disabilities (LD), the manner in which coursework is presented becomes a gatekeeper to reasonable access (Burgstahler, 2008). The Individuals with Disabilities Education Improvement Act of 2004 (IDEIA, Pub. L. No. 108-446) defines LDs as a variety of processing disorders. In the same vein, the National Joint Committee on Learning Disabilities (1991) defines LD as "a heterogeneous group of disorders manifested by significant difficulties in the acquisition and use of listening, speaking, writing, reasoning or mathematical abilities" (p. 20). Specific LD may include dyslexia, dyscalculia (mathematical reasoning disorder), and dysgraphia (writing processing disorder) (Gregg, 2009).

According to Kirk, Gallagher, Coleman, and Anastasiow (2009), "Attention-deficit hyperactivity disorders [ADHD] can be considered a specific form of learning disability related to an individual's inability to attend to or focus on a given task" (p. 115). ADHD is a neurobiological disorder, which affects adults as well as children and is generally characterized by a lack of attention, impulsivity and in some cases hyperactivity (Children and Adults with Attention-Deficit/Hyperactivity Disorder, 2010). Symptoms related to the diagnosis of ADHD must persist at least over a six month period, occur before the age of seven, and must transpire over at least two different environments (American Psychiatric Association, 2000). While ADHD is not a specific LD, individuals with ADHD are likely to experience academic difficulty that may result in school failure. Co-morbidity of ADHD and LD is elevated when attention and academic failure are combined (Al Otaiba & Fuchs, 2006; Pennington, 2004).

Gardner (1983) observed that students with LD and/or ADHD often are asked to focus in ways that oppose their learning strengths, for example, focusing on auditory processing tasks when their strength lies in mnemonic representations. In such instances, the students' executive function becomes limited when

processing weaknesses are the focus of classroom instruction. Such occurrences tend to force these groups of students to take notes rapidly, which may interfere with their ability to focus on listening.

The Americans with Disabilities Act of 1990 (ADA, Pub. L. No. 101-336) ensures that otherwise-qualified students with disabilities receive equal access to postsecondary education. As explained by Gordon, Lewandowsky, Murphy, and Dempsey (2002), "The goal of the ADA, unlike the Individuals with Disabilities Education Act (IDEA) is to provide equal access to programs, services, and facilities, not to ensure entitlement to academic success" (p. 361). Although academic success is not guaranteed to any college student, a lack of supports may be considered a form of exclusion for some students with disabilities since without needed supports they may not have the same access to a postsecondary education as their non-disabled peers (Gregg, 2009). In light of this view, students with LD and/or ADHD may require formal accommodations to enable them to achieve equal access to learning in college courses (Brown, 2006; Mapou, 2009). Burgstahler (2008) defined the term *accommodation* as a "means offering an adjustment or modification to make a product or environment accessible to an individual with a disability" (p. 11). Such formal accommodations may include a variety of instructional and assessment strategies such as repeated modeling of procedures, numerous short breaks during instruction, seating to minimize distractions, flexible scheduling, extra time for assignments and tests, use of instructional techniques that address a variety of sensory modalities, and access to technology. Technology accommodations may include audio textbooks, digital recording of lectures, note takers, and access to copies of course overhead/PowerPoint presentations prior to class presentation (Gregg, 2009; Mapou, 2009).

In science and mathematics courses, additional accommodations might include calculators, computer-assisted instructional software, and large display screens (DO-IT, 2002-2007). Maccini, McNaughton, and Ruhl's (1999) review of research revealed that students with LD can experience difficulties in acquiring and retaining algebraic reasoning, the foundation of most science, technology, engineering, and mathematics (STEM) disciplines. Trammell (2003) found that many students with LD and/or ADHD improved their grades with the support of a variety of accommodations including taping of class lectures and access to textbooks on tape. Given that the types of accommodations and levels of support services available to students with LD and/or ADHD vary by institution, it was not surprising that Madaus (2006) found support services to be a factor in a student's selection of a college. Madaus also found that students with LD who completed college had positive outcomes for post-graduation employment.

With increased scientific research, technological innovations, and the growth of the Internet, many educational experiences for all learners now include computers and other technological devices that may help students learn more efficiently (Domine, 2009). According to Mapou (2009), "Assistive technology and widely available computer software can be very helpful for adults with reading disabilities, written-language disabilities, or ADHD. Universal design using computer software in postsecondary education settings can reduce the need for formal accommodations" (p. 169). Provision of technology by itself may not be sufficient to meet learners' needs. Postsecondary students with LD and/or ADHD have been found to benefit from individualized instruction in the strategic use of increasingly ubiquitous technology learning tools. Parker, White, Collins, Banerjee, and McGuire (2009) asserted that students should attain a level of proficiency with technology "used by the institution and faculty to deliver coursework and communicate with students to succeed in today's postsecondary environments" (p. 133).

The ubiquitous nature of the Internet may provide continuous access to lecture content developed and digitally archived through computers applications. Today, the Tablet PC using innovative digital pen technology provides a tool that educators can use in designing learning environments that may engage most learners. The Tablet PC is a portable computer with a rotating screen locking on top of the keyboard, transforming the notebook computer into a notepad for handwriting directly on the screen. The active digitizer and digital "ink" emulate natural handwriting with options for pen, felt-tip marker, or highlighting representations. While traditional blackboards and whiteboards provide limited access to the critical content displayed, the on-board video recording of a digital whiteboard from the Tablet PC provides a flexible solution for continued access to content establishing better reinforcement for long-term learning strategies. For example, the live annotations on the digital whiteboard can be video

screen captured with a synchronous audio recording of the instructor's lecture.

Two specific software applications of Tablet PC technology were employed throughout this research: Elluminate Live! (Blackboard Collaborate, 2011) and Camtasia Relay (Tech Smith Corporation (1995-2010). These applications were not the focus of the research but tools of implementation that provided recording, playback, and web publishing capabilities. Steinweg, Williams, and Stapleton (2010) found in initial reports that the use of Tablet PCs in postsecondary education has a positive impact on students with a variety of disabilities. Instructors in the STEM disciplines used the Tablet PCs as the tool for recording and archiving course content for student asynchronous online continual access with the goal of aiding efficiency of learning.

Designing an inclusive environment using digital pen-technology and asynchronous online access for diverse populations uses universal design (UD) as its foundation. Nichols and Quaye (2009) stated, "The theory of universal design strives to create optimal conditions for accommodating the changing needs of multiple constituents" (p. 51). "With UD, the consumer is not expected to adjust to the limitations of an inflexible product or environment; rather, the application adjusts to the needs and preferences of any user" (Burgstahler, 2008, p. 7). Universal design can be considered both a process and a goal. As a process, UD is product driven and provides students with options to access a variety of environments. In the present study the product is asynchronous online access, which allows individual students to choose when and how much access is needed. Enhanced instructional access by students with a variety of learning needs is the desired outcome of UD. Burgstahler (2008) noted that applying UD principles results in products and learning environments that are welcoming and useful to groups that are diverse in many dimensions, including gender, race and ethnicity, age, socio-economic status, ability, disability, and learning styles.

The Center for Applied Special Technology (CAST) [n.d] suggests faculty consider the *what, how and why* of learning through multiple means of representation, expression, and engagement when creating curriculum. According to Rose, Harbour, Johnston, Daley, and Abardanell (2008), accessible pedagogy is the cornerstone of Universal Design for Learning. Postsecondary faculty who use digital pen-technology and recordings, which can be archived and accessed later via a web-based location, may increase all students' accessibility to course content in a manner that promotes asynchronous learning. By providing all students with asynchronous usability, or the ability to download lectures, instructor notes, and other vital course components outside of regular class meetings, instructors who offer online archived medium may be providing students the opportunity to study at times more conducive to their individual learning needs. In some cases, this type of access could eliminate the need to disclose a disability or register with an Office of Disability Services altogether. Such an outcome could effectively allow some students to avoid the "documentation disconnect" identified by the National Joint Committee on Learning Disabilities (2007) that often impedes or prolongs the process necessary to receive even basic accommodations such as note-taking and permission to record lectures.

Universal design meets the needs of the community of learners while focusing on access for many individual learners. Rose et al. (2008) stated that Universal Design for Learning is developed to be flexible and "anticipates the need for alternatives, options, and adaptations to meet the challenge of diversity" (p. 46). In light of this observation, Winick and Gomez (2008) stated that Universal Design for Leaning also allowed many students with LD to "disappear" into the general population becoming invisible or unidentifiable as compared to their non-disabled peers. McGuire and Scott (2006) suggested that, as the paradigm of UD continues to develop and as faculty become more attuned to the needs of individual students, certain accommodations could be requested less frequently. Providing asynchronous online access may provide students with LD and/or ADHD an alternative learning environment that engages various modalities meeting the goal of UD. It must be noted that the application of UD will not be fully usable or accessible for all learners (Burgstahler, 2008). However, the goal of providing educational access to diverse groups of learners at the postsecondary level should be considered for individual, group, and environmental appropriateness (Rose et al., 2008).

One approach to providing educational access at the postsecondary level is through asynchronous web-access. Asynchronous web-accessed instruction integrates traditional accommodations provided in postsecondary settings for students with LD with an emerging technology being implemented on college

campuses for the general student population. Asynchronous web-accessed instruction provides students with and without disabilities access to video recordings of computer screen activity including annotated digital whiteboard, PowerPoint slide content, and synchronous audio of lectures presented by the instructor. The recordings are formatted so that they can be accessed from any Internet-connected computer following the class session and can be paused, rewound, and fast-forwarded to locate particular class segments. While traditional accommodations of note takers and audio recorders may identify students with LD or other disabilities, asynchronous online access of digital recordings does not. In this way, video recorded pen-enabled tablet computing can replace traditional accommodations with an integrated audio/video screen recording made available to all students outside a classroom, thus protecting the anonymity of students with non-apparent disabilities such as LD and ADHD. The researchers recognize that audio recorders and the provision of note takers have been supported by access legislation for many years. Although the current research does not explore anonymity issues, the use of asynchronous online course access may potentially enhance a student's anonymity within the educational setting.

Purpose

The purpose of this study was to investigate if asynchronous online access of STEM course content is an effective accommodation for students with LD and/or ADHD in postsecondary STEM courses. This study was part of a larger study funded by the National Science Foundation, called the "Effects of Teaching with Tablet PCs with Asynchronous Student Access in Postsecondary STEM Courses on Students with Disabilities" (NSF RE FRI Award #0726449). For the purpose of this study, LD included any cognitive disorder such as dysgraphia, dyscalculia, or dyslexia as labeled by the state of Tennessee. Students with ADHD were also included in the study due to an elevated risk of academic failure at the postsecondary level.

Simultaneous audio/video computer screen recording is of particular significance in STEM classes. Much of STEM instruction consists of drawing diagrams, solving mathematical equations, or balancing chemical equations. Instructors typically write or draw images on a traditional white board while orally describing the solution or interaction (Stage & Kinzie, 2009). Students can struggle to copy what is on the board while hoping to remember what the instructor said. Due to the pace of instruction and detailed nature of the content, STEM students may make errors in note taking, forget explanations, and leave the lecture with incomplete and/or inaccurate notes. These problems can be magnified for students with LD and/or ADHD whose information processing is less focused or slowed; who may have difficulty discriminating between symbols, signs and numbers; and who may be easily distracted. In a class using asynchronous online access of digital recordings, all students including those with LD and/or ADHD can focus on the lecture/discussion without the burden of taking notes, can access the recordings in locations with minimal distractions, have a complete and accurate record of what was said and demonstrated, and can utilize the recordings to meet their individual ways of learning.

Instructors in the STEM disciplines participating in the study were trained by two special education professors and two technology specialists in the use of Tablet PCs as their instructional white board, the process of uploading course content for asynchronous online access, disability education, and pedagogical instructional practices related to meeting the needs of diverse populations within a postsecondary classroom. A total of 20 instructors were trained in the course of this study, which was implemented across three semesters. Training occurred at the beginning of the semester. Online guides and technology support were provided throughout the study to ensure fidelity of implementation. This study explored the following research question: what is the impact of asynchronous online access of recorded STEM course work as an intervention for students with LD and/or ADHD?

Method

The guiding research question lent itself to the use of qualitative methodology. Merriam and Simpson (1995) posited that a qualitative approach enables a researcher to study how people make sense of and interpret the meanings attached to their words and experiences. Qualitative interviewing methodology enables inquiry and understanding of a societal or human condition, experience, or problem, based on construction of a complex picture that is formed mentally and analyzed inductively (Creswell, 1994). Bogdan and Biklen (2003) explained that qualitative research engages a limited number of participants in

a deep systematic analysis of a phenomenon and is an appropriate research method when desired outcomes include description, interpretation, and a detailed understanding of the phenomenon. The three researchers used face-to-face interviews to better understand the challenges and successes that students with LD and/or ADHD experienced in asynchronous STEM learning environments.

The epistemology for this research was constructionism, the focus being the construction of meaning from the perspectives of students with LD and/or ADHD with regard to their study habits in STEM courses that had asynchronous access. Crotty (1998) stated that constructionism is the view that all knowledge, and therefore all meaningful reality as such, is contingent upon human practices, being constructed in and out of interaction between human beings and their world and developed and transmitted within an essentially social context. This study examined how participants constructed study habits and experiences within the context of asynchronous access of learning material. This inquiry was designed to be a collective case study with each participant being viewed as a unit of analysis. According to Stake (2000), a collective case study is an instrumental case study extended to several cases. An instrumental case study is the examination of a particular case to provide insight into an issue. The case study approach was selected for several reasons. Merriam (1998) and Bogdan and Biklen (1998) postulated that case study research seeks to understand specific issues and problems of practice through a detailed examination of a specific group of people, a particular organization, or a selected activity. To this end, 11 participants were investigated individually as cases and jointly examined to better understand their experiences and study habits in STEM courses that provided access to web-accessed recordings of class content.

Participant Selection

This study sought to identify whether students with LD and/or ADHD who were enrolled in math, biology, and chemistry courses benefited from asynchronous online access to course instruction and materials. Participants were enrolled in one of three different postsecondary institutions. Institutions A and B were two-year community colleges. Institution A served urban students in a large metropolitan area. Institution B served students in a rural area while Institution C was a four-year university located in a rural setting serving students in a Micropolitan area. A micropolitan area consists of core counties with a population between 10,000 and 50,000 persons along with counties surrounding the core county that share a "high degree of social and economic integration with the central county as measured through commuting" (Office of Management and Budget, 2000, p. 82238). The study was limited to institutions within a radius of 100 miles from the researchers. In addition to driving the long distances to conduct interviews in participants' natural settings, a challenge to the study was the frequency with which interview appointments were cancelled or the participants never showed up.

To participate in the study, participants had to meet the following criteria: (a) provided documentation of either an LD and/or ADHD to the Office of Disability Services, and (b) enrolled in a STEM course (math, biology, or chemistry) during the Spring 2008 to Spring 2009 semesters. Students had to have a current diagnosis of an LD and/or ADHD. There are many students at the postsecondary level that have not self-disclosed or may have never been identified as having an LD or ADHD. Nichols and Quaye (as cited in Harper and Quaye, 2009) state, "Statistics on students with disabilities are subject to fluctuation. If students do not disclose their disability, it prevents postsecondary institutions from accessing information about them that may be useful in providing them accommodations and services" (p. 40). During advisement, the Office of Disability Services reviewed student files to determine which students met the criteria to participate in the study. Students were then contacted by the Office of Disability Services. Fourteen students agreed to participate during Spring 2008 to Spring 2009 and signed informed consent. Of the 14 students, 11 agreed to be interviewed at the end of their participation semester. Three of the 14 did not respond to requests to be interviewed. Eleven of the interviewed students were White and one student was African American.

Data Collection

Data collection consisted of face-to-face interviews with each participant and lasted up to 40 minutes. A semi-structured interview with open-ended questions was constructed to aid in data collection. Berg (2001) stated that semi-structured interview guides allowed the interviewer to probe far beyond answers that might be generated by pre-prepared standardized questions. Likewise, Patton (2002) posited that open-ended in-

Table 1

Demographics of Student Participants

Participant #	Institution	Gender/Race	Course Enrolled	Documented Disability
1	Urban CC*	F/Black	BIOL 2020	LD
2	Rural CC*	M/White	BIOL 1120	ADHD
3	Rural U*	M/White	CHEM 1120 BIOL 1120 MATH 1910	LD
4	Rural U	M/White	MATH 1910	LD
5	Rural U	F/White	MATH 1530	ADHD
6	Rural U	M/White	MATH 1130	LD
7	Rural U	F/White	BIOL 1010	ADHD
8	Rural U	M/White	MATH1130 BIOL 1010	LD/ADHD
9	Rural U	M/White	MATH 2110	ADHD
10	Rural U	M/White	CHEM 1110	LD
11	Rural U	M/White	CHEM 1110	LD/ADHD

*Urban CC: Urban Community College; Rural CC: Rural Community College; Rural U: Rural University

terview questions enabled researchers to understand and capture participant's views.

During the interviews, the lead researcher asked the participants about the courses they were enrolled in that allowed access to web recordings, how often they accessed the asynchronous online recordings, whether recordings increased or decreased the time they spent reviewing course materials, whether access of web recording impacted their learning in the course, how web-accessed recording changed their attitudes toward STEM courses in college, and in the future, if they would choose a class that allowed asynchronous online access to recordings as opposed to one that did not. All interviews were audio recorded and transcribed verbatim.

Data Analysis

One of the researcher's challenges is to obtain and verify the true meaning of each participant's responses to the questions asked (Gall, Gall, & Borg, 2003). To begin making meaning of collected data, the 11 interviews were analyzed separately as described by Miles and Huberman (1994) during data reduction, data display, conclusion drawing, and verification phases. The data analysis process helped the researchers approach the data without preconceptions about participants' experiences as well as build a general explanation of study habits of each of the individual cases even though the cases varied in their details. During this process the researchers reflected on the purpose of the study and the guiding research questions as they noted phrases and

words that revealed each participant's experiences.

The researchers then identified text segments that contained the same meaning and sought to derive in vivo codes from transcripts by identifying repetitive, descriptive, and interpretive phrases of participants' experiences, which were then developed into categories such as clarity and convenience. Boeije (2009) stated that *in vivo* codes are not just catchy words; rather, they pinpoint the meaning of a certain experience or event. The *in vivo* codes (i.e., clear, studying strategies/ mechanism, accessibility, good layout, ease of access, better organized, convenience, improved test scores, and confidence) identified in this study produced nine initial categories. Participants' explanations and ideas that had similar meanings were collapsed into the appropriate category. Afterward the researchers wrote memos to themselves describing identified categories to further reduce the data. This process produced a list of all expressions relevant to participants' perspectives, grouped into categories with accompanying text segments that were examples of those categories. Additional text segments identified by the researchers were then added to the relevant category.

After data reduction, the researchers proceeded to use Microsoft Word to display and organize data for case analysis and cross-case analysis. Miles and Huberman (1994) defined cross-case analysis as searching for patterns, similarities, and differences across cases with similar variables and similar outcome measures. Data and similar interactions (e.g., terms like "convenience" "ease of access") in which study participants used related terms to express their experiences were further grouped together into identified categories. The researchers then embarked on developing themes by grouping identified categories that had similar meaning into core themes. For example, "good layout" and "better organized" were collapsed to form the core theme, organization. As the researchers continued sorting the data and identifying relevant core themes, they reviewed the purpose of the study to stay on course.

Researchers seek to incorporate the language and principles of qualitative analysis practices to comprehend a phenomenon of interest in whatever setting they are studying (Patton, 2002). In this study, the researchers sought to reconcile their differing perspectives of data analysis findings and verification phases through triangulation and journaling as suggested by Patton (2002). Miles and Huberman (1994) stated that verification, which is in tandem with conclusion drawing, entails revisiting the data as many times as necessary to cross-check or verify the emergent conclusions. To this end, the researchers reviewed the initial nine categories searching for left-out subtopics, including contradictory points of view and new insights, refining the categories at four different times. During this process we emailed each other the Microsoft Word tables with probable themes representing collapsed categories. From these exchanges, we reduced the nine categories to six core themes: comprehension, organization, asynchronous access, convenience, achievement, and coping mechanisms.

The researchers then embarked on establishing reliability of agreed themes by collaborating with three colleagues involved in qualitative work at their respective institutions (Mays & Pope, 1995). Mays and Pope use the term "reliability" and claim that it is a significant criterion for assessing the value of a piece of qualitative research. To establish the inter-rater reliability of the six core themes, the researchers shared analyzed data with three colleagues through email correspondence over a month. Upon receipt of ratings from colleagues, the researchers calculated the percent agreement and coefficient alpha for each theme as suggested by Banerjee, Capozzoli, McSweeney, and Sinha (1999). Percent agreement reflects the number of times all three raters agreed upon an identified theme as present or absent divided by the total number of their agreements and disagreements, multiplied by 100. Since three raters analyzed the transcripts, the percents agreement expected by chance was 25%. Therefore, agreement greater than 25% supported consistency among the raters. Percent agreements for each theme were: comprehension = 85%, organization = 76%, asynchronous access = 100%, achievement = 87%, convenience = 62%, coping mechanism = 90%. Next, we calculated the coefficient alphas using the three colleagues as items to evaluate the degree of rater consistency. The coefficient alphas for identified themes were as follows: comprehension = 0.89, organization = 0.81, asynchronous access = 1.00, achievement = 0.93, convenience = 0.67, coping mechanism = 0.96. The strong degree of inter–raterreliability, with the exception of convenience, indicated high levels of agreement in how the researchers and raters understood coded comments and the thematic categories into which they were grouped. The raters suggested that we change the name of the core theme "coping mechanisms" to "disability coping mechanism" and "comprehension" to "clarity." These changes were made.

Results

Participant responses collected and analyzed during the study led the researchers to categorize data according to the commonalities and themes that emerged with no observed priority or order. Verbatim quotes from participants are used throughout this section to emphasize core themes. Analysis of student interviews resulted in the emergence of six ways that asynchronous online access to lecture content recorded by professors using Tablet PCs facilitated students' learning in STEM courses. Students felt that the technology enhanced clarity of course concepts and skills, increased organization of course materials, provided asynchronous access, increased convenience, improved achievement, and provided a disability coping mechanism.

Clarity

All the participants perceived clarity as a key component in their learning process. Participants found asynchronous access of course materials to reduce inconsistencies in their own note taking as well as to improve comprehension of class material. Participants observed that asynchronous access was beneficial to visual learners, leading to an increased awareness of instances of instructional materials presented in class. Specifically, Participant 10 stated, "I mean…I could see going over stuff again, and again it made me understand more." Participant 7 also shared the same sentiment by saying, "I would probably read over my notes again, like…if I needed clarification or something." Participant 11 added that he got distracted very easily in class, "…so being able to go back and listen to recordings definitely helped. It cleared a lot of things." Participant 9 had the following to share, "Dr. B. notes, his PowerPoint's, presentations also have his hand scribbled notes down there as well so it is very visual."

According to participants of this study, clarity implied that asynchronous online access of information reduced inconsistencies in class notes, improved comprehension, and brought to realization learning experiences to visual learners, positively impacting their learning. Participants realized that accessing the asynchronous online recordings had a positive overall effect of their perception of STEM related courses.

Organization

Organization implied that, when course content was accessed asynchronously, participants found it to be well structured, helping them study the material. However, Participant 1 expressed frustration by noting, "I think we should have more training or an overview in class first on how to access and use web-based recordings. It is not sometimes easy to get on and figure out how the stuff is put on there." On the other hand, several participants, 11, 9, and 8 thought the material was easily laid out once downloaded.

Participant 11 noted, "I felt it was easy to navigate the web recording, but…I didn't have any trouble with them." Participant 9 stated, "I have looked up the web recording, …they are pretty easy to, I am pretty computer savvy so I don't know, some people may have difficulty than others but it was easy for me." Participant 8 said, "I like how, yeah, the slides were done. It helped me a lot though, if I didn't figure out something, I could just go to the Internet and they had the slides. He had the slides pre-made for class so I could just read what he was saying." Though a majority of the participants stated that materials seemed to be structured once retrieved from the Internet. This helped with studying content intuitively. Participants 4 and 9 observed that some instructors seemed not to know how to use pen technology to present materials in a structured format.

Asynchronous access

STEM-related courses were designed to have an asynchronous component to accommodate students with LD and/or ADHD. In other words, students were provided with class material that was uploaded to a web server for their convenience so that they would be able to access it anytime for studying purposes. Its success depends on the instructor's technical knowledge and maintenance of the transmission medium. Study participants noted that asynchronous access supported their learning habits; however, they pointed out that the venture was dependent on the instructors' ability to understand and operate the technology. In addition, reduction of background noise experienced in web recordings, availability of enough bandwidth and ease of connection to stream the recording, and instructor's voice not synchronized with visual presentation created moments full of frustration for students. As Participant 1 remarked:

> It was kind of difficult to get on…online to listen to that so then when I finally did then one time I couldn't hear nothing….the connection is kind of slow and trying to get exactly where you are supposed to go to get on it for the pop-up screen and then you have to hit something else…if it was more a little accurate or more fast it would have been a little better.

Participants 10 and 9 shared the same viewpoint. Participant 10 stated, "There is always the low signal strength and then it progressively worsens." Participant 9 said:

> You can't always depend on technology; it goes down from time to time. I have had a couple of incidences where its affected my class and I couldn't either get an assignment or view something or couldn't send something to my professors…for some reason it always seem to happen at the worst time.

Convenience

Participants explained that they liked the availability of class lectures and material that met their needs being available on demand. In other words, asynchronous access of course content provided expediency to learning situations for study participants. Participants could study independently and review course notes with more confidence at their own pace without the feel of time constraints and pressures experienced in a typical classroom. Participants also expressed that they never felt comfortable asking questions of the instructor or their friends. Instead, they were able to view the web recording as many times as was necessary to master the material even though it might have been posted by a different instructor. Participant 10 stated:

> …multiple recordings from different instructors teaching same course are helpful because if you don't understand teacher A but you understand teacher B then I'm going to listen to teacher B when I 'm enrolled in A because the way registration goes, sometimes you just can't get the teacher you want

Participant 2 said, "I was a little bit sick and couldn't make it to class. The recordings were definitely beneficial then so, I mean, anytime you may have a circumstance where you can't make it to class then it is encouraging." Participant 1 said:

> If there's something I'm not paying attention to or didn't focus in class, and cannot find it in my notes, I can, you know…I can always go back there, pull it up on the web and keep listening to it over and over again until probably I get a better understanding of it.

Other participants agreed it was convenient to have class materials online. Participant 9 thought it was beneficial to access the notes online; Participant 8 thought it was good to have it online because it showed more, visuals were helpful when studying. Participant 7 stated, "When I didn't understand something I would go back and redo it or sometimes it helped to re-listen to it." On the contrary, Participant 8 pointed out this possible unintended consequence, "It can also get you into the habit of being lazy; like my roommate, he didn't go to class really."

Achievement

Achievement implies that students with LD and/or ADHD are able to recognize an improvement in their study habits as well as anticipate higher test scores and grades. This is evidenced when Participant 10 stated, "Recordings have immensely impacted my learning, again I am a visual learner so it's easier for me to see and hear than just listen." Participant 3 noted, "I could have probably been doing much better on my tests from the beginning if I knew about these recordings, you know. I have an attention and focus issue."

The rest of the participants thought their learning process and appreciation of STEM courses had been positively impacted by the recordings. Participant 11 had previously enrolled for the STEM course, withdrew halfway on medical grounds, and was repeating the STEM course said, "Having taken this class before, I feel I have a better grasp of things…I feel, I feel a lot better about this class than I did last semester," Participant 9 said:

> It helps me feel more confident about the course… the teacher of the course does a very good job teaching it and the web based just reinforces his teaching….if you miss something you can always go back to it. You always have something to reference if you've got a question, if you copied

> something wrong or not, or if you did not get something… It's definitely a tool that when you need it, it's a very, very good tool to have. I'm expecting to get an "A" in this course.

Participant 3 noted, "At first I struggled with it because I was trying, I wasn't used to math on the Internet. I wasn't used to biology…but since I've gotten the hang of it. Like, just adjusting I think it is a good thing."

Disability coping mechanisms

According to the participants of this study, accessing asynchronous online information has helped them self-accommodate the impact of their LD and/or ADHD. Participant 4 said, "I have been brought up to not use my disabilities as a hindrance…, I do like having the accommodations and everything like that. It does make learning easier." Participant 11 stated:

> Web-based recordings have been beneficial in helping me understand concepts better. With some of the things I have, the disabilities that I can't always pay attention one hundred percent, and so being able to go back and catch stuff I missed definitely helps.

Participant 10 reported:

> You can't be expected to have a recording of every lecture or meeting…so it is good to have this opportunity but I also need to be able to learn to cope with it so that when I get into the work field then I can be able to function like everybody else.

Participant 7 acknowledged:

> The class seems to be easy in the beginning and get tougher later on and when you have classes during instructor's office hours you can't go ask him a question. For an individual who is more auditory, online access allows you to go back and review the material while listening to the instructor's voice explaining course content.

Participant 11 perceived online recordings as a back-up and not a tool to be dependent upon while Participant 2 felt asynchronous online access offered more choices for referencing notes and materials online.

Discussion

Historically faculty have focused curriculum development on theory and research while the Office of Disability Services and other student affair offices have focused on pedagogical practice (Harper & Quaye, 2009). The theory of universal design brings together faculty and various student affairs offices through practical pre-planning of classroom instruction, assignments, and anticipated student outcomes. It is important to acknowledge that access to information through UD "does not signify that learning will occur; rather, learning also requires an awareness of students' divergent needs and an understanding of how to enable [students] to reach their potential" (Nichols & Quaye, 2009, p. 51).

While it is not possible to compare the participants' perceptions to all students with LD and/or ADHD, findings of this study align with UD tenets of multiple means of representation, expression, and engagement. Instructors' use of multiple means of expression enhanced students' ability to study course materials. The use of asynchronous online access of recordings could help facilitate the studying of course material by clarifying inconsistencies in a student's class notes. Precision in note-taking can impact comprehension, enhance learning, and result in a higher grade. Online access of lecture material that includes illustrations of key concepts in conjunction with an audio explanation may promote a clearer understanding of course content. In this setting, multiple means of representation occurs when access of course content is available in class as well as outside of class, reducing distractions and clarifying variations in note-taking in the educational setting (CAST, n.d.).

Asynchronous online access of course content helps students with LD and/or ADHD self-accommodate, or successfully cope with their disability within the context of a postsecondary STEM course. Auditory learners can listen to the instructions which may include multiple steps as many times as necessary while visual learners can review the content as needed. CAST (n.d) finds multiple means of expression occurs by allowing the strength of the learner's working memory an opportunity to actively organize information to meet his or her learning needs.

The use of technology in planning and delivering course content in a structured format promotes multiple means of engagement. Rose et al. (2008) found unrestricted access through web-based archived recordings

may lead to increased learning as well as a decrease in the need for specific accommodations. Individual student choice of how and when access occurs meets the requirements of the necessary sustained attention and effort of that student for learning to take place and promotes autonomy (CAST, n.d.).

Implications for Practice

Colleges and universities may need to further address the unique needs of students with LD and/or ADHD at the postsecondary level (Harper & Quaye, 2009). Approaching student needs through UD is a proactive rather than reactive approach (Burgstahler, 2008). Examples of proactively planning instruction for diverse populations including students with disabilities may consist of providing accessible curriculum for students through various delivery methods, providing course content in an accessible manner, and building faculty awareness of diverse populations (Burgstahler, 2008).

Asynchronous online web access of recorded course content could be a part of a proactive approach to designing curriculum in both STEM and non-STEM courses. Providing new, tenure-track, and tenured faculty training opportunities in the planning of course content could address both disability education and asynchronous online access technology. Faculty could be encouraged to use technology to meet the wide range of abilities and learning strengths of students in their courses. This would mean an availability of increased training for all faculty in order to become knowledgeable in the usage and implementation of online recordings accessed via the Web, as well as an understanding of teaching pedagogy that allows the seamless integration of course content and instructional strategies. Higbee (2008) found one of the greatest challenges for faculty "is trying to predict the needs of potential students" (p. 68). It should be noted that students with disabilities also need to assume an active role in their educational choices. Colleges and universities cannot be held responsible for meeting all needs of students. Students need to be aware of their own learning strengths and weaknesses and work toward positive outcomes with self-determined beliefs and practices.

Limitations

As with all educational research, there are limitations to this study that must be addressed. Due to the small number of participants, caution must be used in generalizing findings to larger populations. Participants interviewed were registered through the Office of Disability Services at each institution as having an LD and/or ADHD. However, there possibly were other students who may have qualified to participate in the study but chose to remain undisclosed. Students not registered through the Office of Disability Services were not interviewed. The study may have been strengthened if students without disabilities had been given the opportunity to share their perceptions, too. Also, students with other documented disabilities such as Asperger's syndrome, post-traumatic stress disorder, or psychiatric disorders may have provided deeper insights into the use of asynchronous online course content as an accommodation. It should also be noted a total of 44 students with LD and/or ADHD (as defined for the purpose of the study) chose to participate in the larger NSF study. Of the 44 participants, 24 were in experimental STEM courses with the accommodation. Although multiple timeslots were available for student participants, only 11 students of the 24 were able to schedule interviews.

Conclusion

Asynchronous online access of course curriculum in the STEM disciplines appears to be helping students gain knowledge of course content. Universally designed curriculum may include asynchronous online access of recorded course content. Further research is needed in the area of asynchronous online access, UD, and students with disabilities.

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About the Authors

Laura M. Graves received her undergraduate degree in Special Education from the University of Tennessee and Ph.D. from Tennessee Technological University. Her experience includes 18 years of teaching in both special education and general education classrooms in Tennessee. She has served as a cadre member for Reading First; serves on the Disability Services ADA Advisory Committee; serves as the corresponding secretary for the TN-IDA; serves as a mentor for the Student Council for Exceptional Children; and is currently the BASE-TN Service Obligation and Employment Verification Coordinator. She served as the PI for the *Effects of Teaching with Tablet PCs with Asynchronous Access in Post-Secondary STEM Courses on Students with Learning Disabilities* (TTASA-SWLD) [award #0726449]. She is currently an assistant professor in the Department of Education at Tennessee Technological University. She can be reached by email at: lgraves@tntech.edu

Paul A. Asunda received his BA degree in Education from Kenyatta University in Nairobi, Kenya, and Ph.D. from the University of Georgia. He is currently an assistant professor in the Department of Workforce Education at Southern Illinois University Carbondale. Dr. Asunda teaches web-based courses that seek to prepare individuals to be conversant with different technological trends and how to integrate them at their place of work. His research focuses on investigating best practices in teacher education and preparation in the areas of Career/Technical Education. Dr. Asunda is also involved in research that seeks to integrate; mathematics, science, and technology (STEM) related activities in the workforce education curriculum as it relates to preparing a workforce that is responsive to 21st century work environments. He can be reached by email at: PAsun07@siu.edu

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Stacey Plant received her BA degree in web design from Tennessee Technological University. Her experience includes working as a project manager of custom web development projects for the Technology Institute and serving as the technical programmer for TTASA-SWLD research grant through the National Science Foundation. She is currently an instructional media specialist for the Technology Institute at Tennessee Tech and self-employed web developer servicing higher education affiliated organizations. Her research interests include progressive enhancement and responsive design with focus on accessibility in web development. She can be reached by email at: splant@tntech.edu

Chester Goad, received both his BS degree in secondary education and his M.A. degree in instructional leadership from Tennessee Technological University and is currently a doctoral candidate at the University of the Cumberlands. His experience includes having worked as a teacher and administrator in public and private schools, and as congressional projects director within the U.S. House of Representatives. He has over ten years experience in higher education in both community college and university settings and he is currently the President of TN-AHEAD. In addition to adjunct teaching, he currently serves as Director of Disability Services for Tennessee Technological University. His research interests include: universal access initiatives, campus and community collaboration, transition, academic coaching, leadership and public policy. He can be reached by email at: cgoad@tntech.edu