Smart Universities and their Impact on Students with Disabilities

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Abstract

Smart Universities and Smart Classrooms are gaining popularity and will be a wave of the future. To better educate all students (on campus and distant) universities will need to approach education and how we teach students differently. In addition, students are more technological than ever before and are demanding new and innovative ways to learn. This paper presents some new and innovative ideas about how students with disabilities might also benefit from Smart Classrooms. Even though they are not the majority of learners in our classes, by incorporating smart technologies we believe many of these students will also benefit.

Keywords: Smart Classroom; Disabilities; Learning Disabilities; Visual Impairment; Hearing Impairment; Technology; Hardware; Software

Introduction

Smart universities and smart classrooms create multiple opportunities for students to learn material in a variety of ways through technology. In addition, they can give access to materials in a variety of ways to all students. Although not designed or even conceptualized to benefit students with disabilities, this concept would definitely have an impact on the learning and access to material for students with many different types of disabilities. A smart classroom is an intelligent classroom for teachers involved in distant education that enables teachers to use a real classroom type teaching approach to teach classroom-based and distant students. "Smart classrooms integrate voice-recognition, computer-vision, and other technologies, collectively referred to as intelligent agents, to provide a tele-education experience similar to a traditional classroom experience" [1].

History

Smart universities and smart classrooms primary focus is in education, but they also drive the change in other aspects such as management, safety, and environmental protection. The availability of newer and newer technology reflects on how the relevant processes should be performed in the current fast changing digital era.

This leads to the adoption of a variety of smart solutions in university environments to enhance the quality of life and to improve the performances of both teachers and students. Nevertheless, we argue that being smart is not enough for a modern university. In fact, all universities should become smarter in order to optimize learning. By "smarter university" we mean a place where knowledge is shared between employees, teachers, students, and all stakeholders in a seamless way [2].

Smart Classrooms

The implementation of a smart classroom (SmC) and smart learning environment (SmLE) model could potentially have a huge impact on the learning of students with disabilities in general and more specifically students with learning disabilities, speech or language impairments, visual impairments, and hearing impairments. Many of the smart features of SmC and SmLE are the exact areas where students with disabilities have documented weaknesses. Most noted are deficiencies with learning, inferring, and self-organizing. Thus, the SmC and SmLE should be considered when working with all students, especially students with disabilities.

In order for smart classrooms to be effective and efficient there are certain levels that should be addressed. These levels or features should guide us when developing smart classrooms. In doing so, we can then identify the most effective hardware, software, pedagogy and learning activities for all students. See Table 1 for a description of levels of smartness. For students with disabilities, this will be very beneficial to them as many times they have difficulties in classroom learning environments with the smartness levels addressed by smart classrooms.

Smartness levels (i.e. ability to ...)	Details
Adapt	Ability to modify physical or behavioral characteristics to fit the environment or better survive in it.
Sense	Ability to identify, recognize, understand and/or become aware of phenomenon, events, objects, impacts, etc.
Infer	Ability to make logical conclusion(s) on the basis of raw data, processed information, observations, evidence, assumptions, rules, and logic reasoning.
Learn	Ability to acquire new or modify existing knowledge, experiences, behavior to improve performance, effectiveness, skills, etc.
Anticipate	Ability of thinking or reasoning to predict what is going to happen or what to do next.
Self-organize	Ability of a system to change its internal structure (components), self-regenerate and self-sustain in purposeful (non-random) manners under appropriate conditions but without an external agent/entity.

Table 1: *Classification of levels of "smartness" of a smart system [3,4].*

Considerations for Students with Disabilities

The implementation of a smart classroom (SmC) and smart learning environment (SmLE) model could potentially have a huge impact on the learning of students with disabilities in general and more specifically students with learning disabilities, speech or language impairments, visual impairments and hearing impairments. Many of the smart features of SmC and SmLE are the exact areas where students with disabilities have documented weaknesses. Most noted are deficiencies with learning, inferring, and self-organizing. Thus, the SmC and SmLE should be considered when working with students with all of these disabilities [5]. For example, see Table 2 for some examples of objectives, hardware, and software that could be beneficial to students with disabilities [6].

Objectives

- Seamlessly connect several distant smart classrooms to share lectures and information via networking.
- Seamlessly connect various types of users' mobile smart devices and technical platforms; provide scalability and timely updates of software systems and applications used by various users.
- Automatically record all class activities and provide students with videos and post-class review activities. For example, to review/learn content at students own pace and comfort level.
- Accommodate, adapt and implement the newest and emerging technologies and innovative trends. For example, use face recognition, speech recognition, noise cancellation, and gesture recognition software.
- Provide voice recognition for students; quality and fast automatic translation from the English language to other languages, and vice-a-versa.
- Empower the instructor with voice recognition, face recognition, gesture recognition software as well as smart pointing devices and boards to navigate, edit and display information on smart boards.
- Provide a regular face-to-face learning like experience to online/remote students logging into a session in a smart classroom or smart lab.

Hardware
- Have an array of video cameras installed to capture main classroom activities, movements, discussions, expressions, gestures, etc.   - Have ceiling-mounted projector(s) with 1 or 2 big size screens to display main activities in the actual classroom; in some cases – 3D projectors may be used.   - Have student boards (big screen displays or TVs) to display images of remote/online students from different locations.   - Use Bluetooth and Internet enabled devices like cell phones, smart phones, personal digital assistant's (PDAs) and laptops to facilitate communication and information/data/notes exchange from professor to student and amongst students.   - Incorporate sensors (location detection, voice detection, motion sensors, thermal sensors, humidity, sensors for facial and voice recognition, etc.) into the classroom.
Software
- Use a learning management systems (LMS) or have access to a university wide LMS.   - Use advanced software for rich multimedia streaming, control and processing.   - Incorporate software systems to address needs of students with disabilities. For example, students with visual impairments (speech and gesture based writing/editing/navigation and accessibility tools to facilitate reading and understanding).   - Use smart cameraman software (for panoramic cameras).   - Use recognition software: face, voice, and gesture.   - Use motion or hand motion stabilizing software.   - Use noise cancellation software.

Table 2: Objectives, Hardware and Software for Students with Disabilities.

Benefits to Students with Disabilities

When looking at smart universities/smart classrooms and the possible impact on students with disabilities the outlook is very good. Not all students with disabilities will probably attend a university, but it is very likely that students with learning disabilities, speech or language impairments, visual impairments, and hearing impairments will potentially attend a university. This group of students makes up 58% of the total population of students with disabilities and about 11% of the total university school population [7].

Characteristics of Students with Disabilities

During the 2011 - 2012 school year approximately 6,401,000 students with disabilities were in public schools comprising nearly 13% of total school enrollments. Of this, approximately 36% of students with disabilities, and 5% of the total student body, have been identified with a specific learning disability [7], which is nearly double the next most identified population (speech or language impairments) of students with disabilities. For students with visual impairments and hearing impairments they comprise 2% of the total school population. In the late 1980s and early 1990s there was a push to remove students with disabilities from the general education classroom to offer them more individualized attention and instruction, but changes in federal legislation has significantly impacted the number of students with disabilities currently being served in the general education classroom setting. Approximately, 63% of students with learning disabilities spend most of their school day in general classes [8]. This is by far the largest group of students with disabilities and because of this large number most general education teachers will be working with these students. This shift in instructional settings brings forth a set of challenges especially since most general education teachers have limited schooling on the instruction of students with disabilities. In regards to students with learning disabilities, many teachers assume that these students should be able to master academic content in

the inclusive classroom with relatively few supports [9] because their disability is usually not visible. On the contrary, these students many times require more intensive support systems to be successful.

Learning Disabilities

Learning disabilities are associated with many different problems. These include difficulties in listening, reasoning, memory, attention, selecting and focusing on relevant stimuli, and the perception and processing of visual and/or auditory information. These perceptual and cognitive processing difficulties are assumed to be the underlying reason why students with learning disabilities experience one or more of the following characteristics: reading problems, deficits in written language, and underachievement in math [10]. Not all students with learning disabilities will exhibit these characteristics, and many pupils who demonstrate these same behaviors are quite successful in the classroom. Children with learning disabilities are a heterogeneous group. These children are a diverse group of individuals, exhibiting potential difficulties in many different areas. For example, one child with a learning disability may experience significant reading problems, while another may experience no reading problems whatsoever, but has significant difficulties with written expression. Learning disabilities may also be mild, moderate, or severe which complicates instruction for these students in the classroom even further.

Reading Difficulties

Difficulty with reading is by far the most common characteristic of students with learning disabilities. It is estimated that 90% of all children identified as learning disabled are referred for special education services because of reading problems [11]. Children who fail to learn to read by the first grade tend to fall farther and farther behind their peers, not only in reading but in general academic achievement as well. For example, longitudinal studies have found that 74% of children who are diagnosed as learning disabled because of reading problems remain disabled in the ninth grade [12,13]. Common difficulties in reading include: poor decoding skills, poor reading fluency, a slow reading rate, poor comprehension and/or retention, difficulty integrating new ideas to existing knowledge, and extreme difficulty understanding words or grammar.

Reading Comprehension Difficulties

Students with learning disabilities often have difficulties with reading comprehension [14]. These children often lack the skills required for understanding text and have poor word-analysis skills [15]. Reading comprehension refers to a student's ability to understand what he or she is reading. Some students with reading comprehension difficulties are able to read a passage so fluently that you might assume they were highly proficient readers. However, when they are asked questions about what they have read, they have little or no understanding of the words.

Written Language Difficulties

Many students with learning disabilities have problems with writing and spelling. When compared to their peers without disabilities, students with learning disabilities perform significantly lower across most written expression tasks, especially vocabulary, grammar, punctuation, and spelling [16]. Many of these students use a "retrieve-and-write" approach in which they retrieve from immediate memory "whatever seems appropriate and write it down" [17, p. 295], with minimal planning, effort, and metacognitive control [18] to produce a quality written product. These students seldom use the self-regulation and self-assessment strategies of competent writers: setting a goal or plan to guide their writing, organizing their ideas, drafting, self-assessing, and rewriting. As a result, they produce poorly organized compositions containing a few poorly developed ideas [19]. Common writing deficits include: poor writing fluency, unable to compose complete, grammatical sentences, difficulty organizing written information, poor handwriting, and extremely weak proofreading skills.

Math Difficulties

Mathematics is yet another area that some students with learning disabilities have difficulty. Although disorders of reading have traditionally received more emphasis than problems with mathematics, the latter are gaining a great deal of attention. Authorities now recognize that math difficulties are second only to reading disabilities as an academic problem area for students with learning disabilities

[20]. Common deficits in mathematics include: poor mathematical fluency, difficulty memorizing multiplication tables, Difficulty identifying multiples and/or factors, poor basic calculation skills, difficulty understanding word or application problems, poor understanding of mathematical concepts, the inability to transfer basic mathematical concepts to solve problems with unpredictable information and the inability to use basic facts within more complex calculations.

Spelling Difficulties

Spelling is another area, related to writing, that students with learning disabilities have difficulty. Spelling is the ability to use letters to construct words in accordance with accepted usage. Spelling ability is viewed by some teachers and school administrators equally with other academic skills. Being a poor speller does not necessarily mean that a child has a learning disability, however, when poor spelling occurs with poor reading and/or arithmetic, then there is reason for concern. It appears that many of the learning skills required for good spelling are the same ones that enable students to become good readers. Learning to spell is a developmental process, and young children go through a number of stages as they begin to acquire written language skills. Writing begins in the preschool years as young children observe and begin to imitate the act of writing. Common deficiencies in spelling include: frequent spelling errors of high frequency words, extreme difficulty with homonyms and/or regular spelling patterns, no understanding of the relationship of phonics to written language, no understanding of common spelling rules, and an inadequate understanding of phonics even with instruction.

Students with Speech or Language Impairments [21-23]

The characteristics of speech or language impairments will vary depending upon the type of impairment involved. There may also be a combination of several problems. Students could have difficulties with articulation (difficulty making certain sounds), fluency (something is disrupting the rhythmic and forward flow of speech), or voice (problems with the pitch, loudness, resonance, or quality of the voice). Students may also have difficulties with language. Language has to do with meanings, rather than sounds. A language disorder refers to an impaired ability to understand and/or use words in context [21]. A child may have an expressive language disorder (difficulty in expressing ideas or needs), a receptive language disorder (difficulty in understanding what others are saying), or a mixed language disorder (which involves both). Some characteristics of language disorders include: 1) improper use of words and their meanings, 2) inability to express ideas, 3) inappropriate grammatical patterns, 4) reduced vocabulary, and 5) inability to follow directions. Children may hear or see a word but not be able to understand its meaning. They may also have trouble getting others to understand what they are trying to communicate. Delays and impairments in communication may range from so subtle that they have little or no impact on daily living and socialization to the inability to produce speech or to understand and use language. However, because of the importance of language and communication skills in a child's development even mild to moderate impairments or disturbances can have a profound effect on all aspects of life, sometimes isolating children from their peers and their educational environments.

Students with Visual Impairments

Total blindness is the inability to tell light from dark, or the total inability to see. Visual impairment or low vision is a severe reduction in vision that cannot be corrected with standard glasses or contact lenses and reduces a person's ability to function at certain or all tasks. Legal blindness (which is actually a severe visual impairment) refers to a best-corrected central vision of 20/200 or worse in the better eye or a visual acuity of better than 20/200 but with a visual field no greater than 20° (e.g., side vision that is so reduced that it appears as if the person is looking through a tunnel) [24]. Being able to see gives us tremendous access to learning about the world around us. That's because so much learning typically occurs visually. When vision loss goes undetected, children are delayed in developing a wide range of skills. While they can do virtually all the activities and tasks that sighted children take for granted, children who are visually impaired often need to learn to do them in a different way or using different tools or materials. Central to their learning will be touching, listening, smelling, tasting, moving, and using whatever vision they have [25].

Students with Hearing Impairments

The term "hearing impaired" refers to any person with any type or degree of hearing loss. The term may be used with qualifying adjectives such as "mild," "moderate," "severe," and "profound" to denote the degree of impairment. "Deaf" refers to a hearing-impaired person in whom the auditory sense is sufficiently damaged to preclude the auditory development and comprehension of speech and language with or without sound amplification. "Hard of hearing" is used to define a hearing-impaired person in whom the sense of hearing, although defective, is functional with or without a hearing aid and whose speech and language, although deviant, will be developed through an auditory base. The major challenge faced by students with hearing impairments is communication. Hearing-impaired students vary widely in their communication skills. Age of onset plays a crucial role in the development of language. Persons with prelingual hearing loss (present at birth or occurring before the acquisition of language and the development of speech patterns) are more functionally disabled than those who lose some degree of hearing after the development of language and speech. Many students with hearing impairments can and do speak. Most deaf students have normal speech organs and have learned to use them through speech therapy. Some deaf students cannot monitor or automatically control the tone and volume of their speech, so their speech may be initially difficult to understand. Understanding improves as one becomes more familiar with the deaf student's speech pattern [26].

Smart Classroom and Students with Disabilities

Given the difficulties that students with disabilities encounter during their lives and in school the SmC and SmLE would benefit them and help them learn more efficiently and effectively. Where traditional classrooms do not specifically address the levels of smartness unless specific lessons focus on them, the implementation of smart classrooms and learning environments would be suggested to meet the difficulties students with disabilities typically encounter. This way, the exact areas that are of difficulty for students with disabilities would be addressed often and continuously in the classroom. We know the more opportunities provided to students will give them a better chance to learn so having this type of system implemented and part of daily instruction would give the more practice and learning situations to improve the exact areas that they need to improve and work on. For example, see Table 3 for an example of how SMART Boards can impact students with academic difficulties.

Reading Comprehension
• Enlarging text on the SMART Boards to make it more legible for the student.   • Highlighting parts of the text with a digital highlighter or the SMART pen tools function.   • Using the "Spotlight" feature to only reveal certain, relevant areas of text.   • Integrating a SMART Document Camera to display text book pages and other hard copy literature on the SMART Board for students.   • Change text colors and backgrounds to make it more readable on the SMART Board.
Writing Comprehension
• Students using the SMART Boards can write on it using a finger, a pen from the SMART pen tray or a soft object like a tennis ball or hacky sack to practice their handwriting. The SMART Notebook software can then convert these handwritten letters to text using its handwriting recognition capabilities.   • Teachers can show pre-lined paper templates on the SMART Board to make it easier for students to keep their writing on the SMART Board straight.   • Teachers can help students with constructing letter forms by asking them to trace over built in alphabet letters and numerical symbols that are included with the SMART Notebook Software function.   • Students can annotate over web pages, images and electronic documents on the SMART Board to practice their writing skills [27].

Table 3: Impact of SMART Boards on Academic Difficulties.

Considerations for Technology in SMART Classrooms

Although we cannot create an exhaustive list of software and hardware technologies that should be incorporated into all SMART Classroom, we can suggest some things to consider to help all students be successful. One must realize that one technology will not necessarily work or be effective with all students with disabilities, but when choosing software, one must choose the software that will benefit the most students. As students enter your classrooms with more specific needs, those specific needs can be dealt with at that time. Below are some examples of possible technologies for students with disabilities. See Table 4 for examples for students with learning disabilities.

Reading Assistive Technology	
• Text-to-Speech • Wynn Reader (from Scientific Freedom) • TextAloud (from NextUp Technologies) • NaturalReader (from AT&T) • ReadPlease (ReadPlease Corporation) • Kurzweil 3000 (Kurzweil Educational Systems, Inc.) • Dragon Naturally Speaking from Nuance	
Writing Assistive Technology	
• Neo2 • Writers Plus • Inspiration® • Kidspiration • Webspiaration	
Math Assistive Technology	
Calculators	Four function, graphing and scientific calculators
Manipulatives	Geoboards, Cuisenaire rods, pictorial representations, and symbols and virtual manipulatives
Computer-Assisted Instruction	Math Forum at Drexel http://mathforum.org/ arithmetic/arith.software.html [28]

Table 4: *Technologies to Aid Students with Learning Disabilities.*

Speech and Language Impairments. These consist of problems in communication and related areas such as oral motor function. Delays and impairments may range from so subtle that they have little or no impact on daily living and socialization to the inability to produce speech or to understand and use language. However, because of the importance of language and communication skills in a child's development even mild to moderate impairments or disturbances can have a profound effect on all aspects of life, sometimes isolating children from their peers and their educational environments. See Table 5 for examples for students with speech or language impairments.

Smart Classrooms can help students with disabilities overcome their challenges. There are many forms of software and hardware available and we will present some examples in Tables 6 and 7 for students who have vision or hearing difficulties. This is not an exhaustive list, but some examples to provide a context.

Software/Hardware Systems	Description
DynaVox 3100	The DynaVox 3100 is a hardware/software application which assists the user in carrying a conversation by speaking for them. Words, pictures, sentences and ideas can be selected via a touch screen, mouse, joystick and multiple switches. The DynaVox can also be used in multiple languages. This communication device will greatly reduce the frustration for children who cannot speak or whose speech is unrecognizable [29].
CH-7KIVORY	This is a handset designed to assist someones weak speech by amplifying their outbound speech. An example of how this type of technology would assist a student is if they were using a telephone for research, interviewing a professional as well as for many other educational purposes [30].
Chattervox	This is a portable voice amplification system designed to raise the vocal output of people with temporary or permanent voice impairments. This device can assist students who cannot produce enough decibels naturally so that they can be heard [31].
Servox	This is an artificial larynx. It will assist anyone who has lost their voice due to injury or illness as well as those who have to rest their vocal cords or are attached to a respiration device [32].

Table 5: *Technologies to Aid Students with Speech or Language Impairments.*

ZoomText	Magnifies text and graphics programs. Magnify the full screen, a portion of the screen or a single line at a time.
InLARGE	A screen magnification software package for low vision and Macintosh users who are learning disabled. The program features the ability to enlarge any portion of the screen from 2 to 16 times the normal size.
Lunar	Lunar is the world's leading screen magnification program for computer users. It has a number of advanced features to help you manage the enlarged screen more efficiently. Magnification from 2x to 32x normal size with five different viewing modes.
Screen Readers	JAWS, Job Access With Speech, is the world's most popular screen reader, developed for computer users whose vision loss prevents them from seeing screen content or navigating with a mouse. JAWS provides speech and Braille output for the most popular computer applications on your PC.
Duxbury	A Grade 2 braille editing and translation software program. It is available in versions for DOS, Windows, and Macintosh computers. Duxbury is easy to use and is compatible with speech and braille output. It supports dozens of word processors through highly accurate ASCII and WordPerfect import bridges.
Kurzweil 1000	Software that works on your personal computer and a scanner to convert the printed word into speech. It has the ability to find key words or phrases within a document, editing of scanned text, magnification of scanned documents to accommodate users with visual impairments, and the ability to specify unlimited bookmarks within a document [33].

Table 6: *Technologies to Aid Students who are Visually Impaired.*

FM systems	Use radio signals to transmit amplified sounds. They are often used in classrooms, where the instructor wears a small microphone connected to a transmitter and the student wears the receiver, which is tuned to a specific frequency, or channel. FM systems can transmit signals up to 300 feet and are able to be used in many public places.
Infrared systems	Use infrared light to transmit sound. A transmitter converts sound into a light signal and beams it to a receiver that is worn by a listener. The receiver decodes the infrared signal back to sound.
Handwriting Recognition	There are commercially available products that convert hand written materials into computer-generated text. Depending on the device, the information can be saved and printed as written text or can convert the hand written materials into printed text for easier reading similar to a voice recognition system.
Dragon Naturally SpeakingTM:	A voice recognition software package that was developed for the general public to use. It can be beneficial for deaf and hard of hearing individuals by creating text documents out of voice files [34].

Table 7: *Technologies to Aid Students who are Hearing Impaired.*

Conclusion

Smart universities and smart classrooms can create multiple opportunities for students with and without disabilities to learn material in a variety of ways. Although not designed or even conceptualized to benefit students with disabilities, this concept would definitely have an impact on the learning and access to material for these students. Their primary focus is in education, but they also drive the change in other aspects such as management, safety, and environmental protection.

The implementation of a smart classroom (SmC) and smart learning environment (SmLE) model could potentially have a huge impact on the learning of students with disabilities in general and more specifically students with learning disabilities, speech or language impairments, visual impairments, and hearing impairments. Many of the smart features of SmC and SmLE are the exact areas where students with disabilities have documented weaknesses.

The performed research, helped us identify new ways of thinking and our research findings enabled us to make the following conclusions: (1) Smart Universities and Smart Classrooms can impact students with disabilities even though they are not the focus, (2) Many technologies geared towards students without disabilities will actually impact the learning of students with disabilities, (3) Some students with disabilities may need specialized technology to be successful, (4) Some technologies focusing on the success of students with disabilities may help students without disabilities to be successful, and (5) More research needs to be completed addressing students with disabilities. Based on obtained research findings and outcomes, more research needs to be conducted focusing on Smart Classrooms, specifically hardware and software solutions, and students with disabilities.

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