Assistive Technology-based Solutions in Learning Mathematics for Visually Impaired People: Exploring Issues, Challenges and Opportunities

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ABSTRACT

Nowadays, technology provides many effective and affordable solutions to help visually-impaired people acquire mathematical skills. This poster reviews technology-based mathematical learning solutions for visually-impaired people, and briefly analyses the issues, challenges and limitations of existing techniques and applications. Based on these findings, it is proposed that audio feedback, tactile displays, accessible math applications, a supportive academic environment and digital textbooks can make it easier for visually-impaired people to learn mathematics.

INTRODUCTION

At present, technology can be used to overcome many challenges faced by visually impaired people. They can use technology to perform routine, daily tasks such as communication with their friends, accessing online information, and e-learning. Several studies show that the use of technology improves the productivity of learning capabilities and enhances quality of life among visually impaired students. Technology typically takes the form of a smartphone or computer application, electronic device or web portal that allows visually-impaired students to live independently.

Currently, interaction with computers and smartphones is predominantly based on vision, which is not useful for blind users and less useful for those who are visually impaired. Similarly, in educational institutes, teaching methodologies are heavily dependent upon visual information i.e., instructor gestures, slide shows, writing and sketching on a board.

Mathematics has an important role in education. Learning mathematics is necessary from primary level to higher studies. Usually, mathematics has rich visual content and information which is inaccessible to visually impaired students. During mathematical learning, visually impaired students have trouble in recognition of symbols, performing arithmetic operations, identifying equations and understanding graphs.

Technology provides an opportunity for visually impaired students to access beneficial information by using Audio-based interfaces, tactile devices and Braille. This study reviews existing applications and techniques aimed at people with a visual impairment learning mathematics, and considers possible future developments.

PREVIOUS WORK

We have reviewed previous work in this field and identified ten applications which represent the current state-of-the-art in educational technology designed to help visually-impaired people learn mathematics. They are: Math Robot□™, Draw2Measure Protractor, Slapstack Math, Practice2Master Fraction□s, UAbacu□s, Math Melodies, TouchMath Counting, i-Math, iCETA Tangible Math and AudioMath and extracted their common features. Table 1 summarises the features offered by these applications. □□□□□□

Table. 1. Conceptual model of learning mathematical skills by using Assistive Technology.

Application Name	Interactive interface	Multiple modes	Magnification	VoiceOver support	Braille support
Math Robot□™	✓	✓	✓	✓	✓
Draw2Measure Protractor□	✓	×	×	✓	×
Slapstack Mat□h	✓	✓	✓	✓	×
Practice2Master Fraction□s	✓	✓	✓	✓	×
UAbacu□s	✓	✓	×	✓	×
Math Melodies	✓	✓	×	✓	×
TouchMath Counting	×	×	✓	✓	×
i-Math	✓	✓	×	✓	✓
iCETA Tangible Math	✓	×	×	✓	✓
AudioMath	✓	✓	✓	✓	×

VISUALLY IMPAIRED STUDENTS AND MATHEMATICS EDUCATION

Figure 1 provides a conceptual model of learning mathematical skills using Assistive Technology. Visually Impaired users interact with the AT using the senses of hearing and touch. They can also communicate with other devices, learning environments, people and their teachers using AT. This model shows that AT empowers visually impaired user to significantly enhance their mathematical skills.

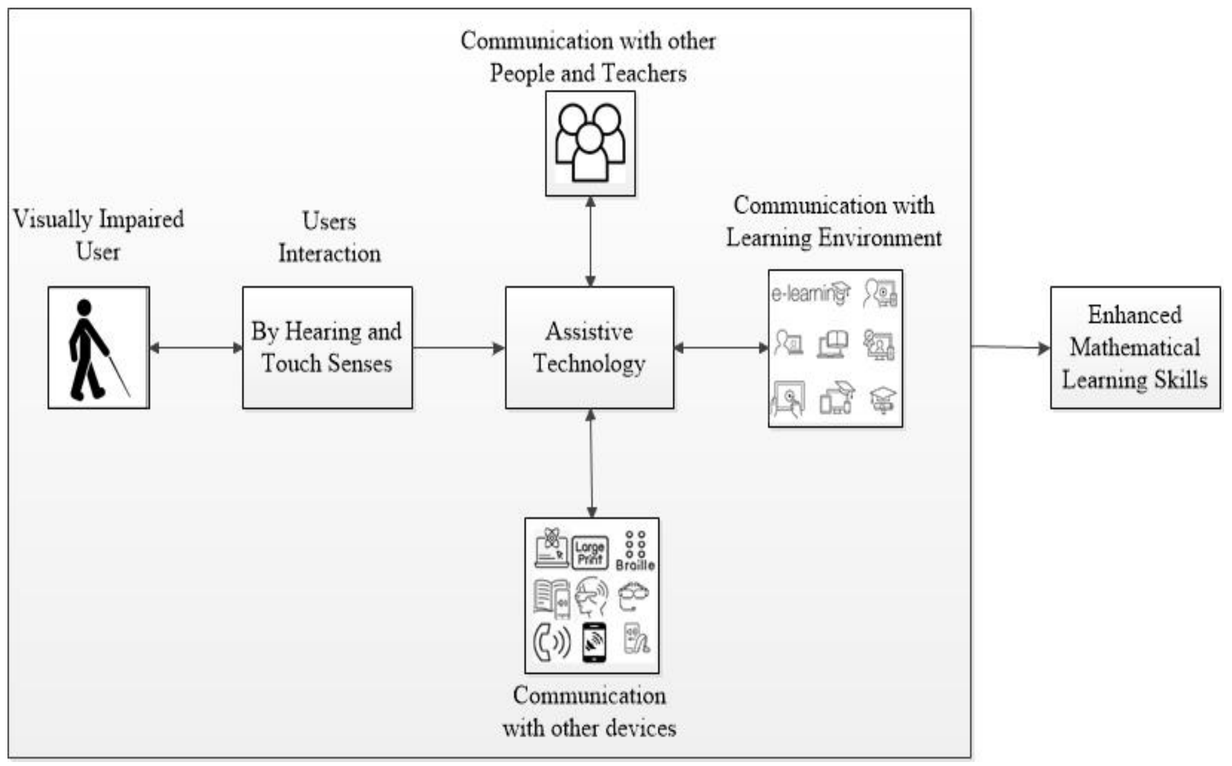

Fig. 1. Conceptual model of learning mathematical skills by using Assistive Technology.

Figure 2 shows that nine of the applications reviewed have interactive interfaces, seven offer multiple modes, five offer magnification, three applications have Braille support, and all ten have VoiceOver support.

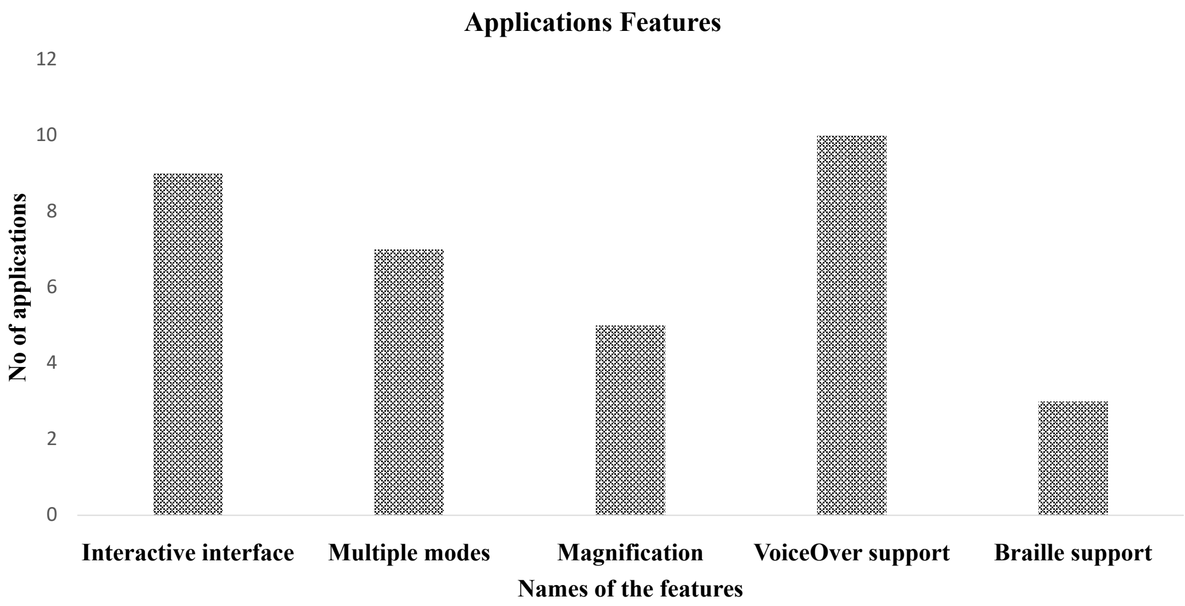

Fig. 2. Math learning applications features

FUTURE DIRECTIONS AND RECOMMENDATIONS

Recent innovative technologies use hearing, haptics and multimodal combinations of senses to help visually-impaired people learn mathematics. Haptic feedback is particularly useful because, in absence of vision, it can be used with visual input to construct mathematical learning systems.

The developer of apps and researchers should bear in mind that every student - whether visually impaired or not - has a different level of knowledge and intellectual abilities. One of the most exciting developments in educational technology in recent years has been the introduction of adaptive systems which seek to identify each individual's learning abilities and tailor the educational experience accordingly. This opens up the possibility of developing AI-based systems which not only vary the content of the learning material to suit individual learners, but also vary the sensory modality used to deliver instruction. In this way we can begin to move educational tools away from the concept of Assistive Technology - which has often been seen to lead users into technical 'ghettos' - and towards the ideal of Universal Design, offering solutions which work for everyone.

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