

The Development of an Application that supports Body Awareness for Children with Visual Impairments and Additional Disabilities

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Abstract

The manuscript reports a case study of a design-based research effort to create an app that promotes body awareness among students with visual impairments (VIs) and additional disabilities. Since 2012, a multidisciplinary team has been developing and testing an app called "Body Awareness through Movement and Music," designed to help children with VIs and additional disabilities improve their body awareness. The app is embedded with features grounded in structured movement routine (SMR) theory. The research effort examines whether a well-designed, intuitive user interface can support improved body awareness of students with VIs and multiple disabilities when used within the itinerant teaching model. A prototype of the app was presented at an international conference where attendees reacted positively to the possibility of using the tool to support body awareness. The prototype was used in a case study with one participant through a multi-sensory approach, with consistency and repetition. Initial findings indicate use of the app provided a SMR that enabled the participant to exhibit appropriate behavior.

Keywords

Body awareness, Visual impairment, Movement routines, Multiple disabilities, Music and movement.

Body awareness and spatial concepts are aspects of orientation and mobility (O&M) that are usually learned incidentally by typically developing children as they interact with their environments. However, children who are blind miss out on these developmental aspects unless timely intervention is provided. Golledge (1993) observed that the ability to travel independently and interact with the wider world is one of the greatest challenges for people with visual impairments (VIs). Similarly, Bruce et al. (1991) found that 20% of the young people who were registered as blind in the UK had not left their homes in one week, only 34% had traveled locally and only 41% had left their homes alone and on foot. Body awareness refers to the names, functions and movements associated with each body part (Fazzi and Petersmeyer, 2001; Maloney, 2016) and it requires that a person

understands the spatial concepts that are necessary to determine the position of one's body in relation to the locations of other people and objects, and within the environment.

According to Fiehler and Rosler (2010), the visual, auditory, tactile, vestibular and proprioceptive sensory systems work in cooperation to guide movements within a space. Similarly, Sherrington (1906) described proprioception as the process in which information concerning the body's position is received and analyzed through continuous feedback to the central nervous system (CNS) from the receptors in the joints. Therefore, any interference with the sensory systems or the CNS may affect the development of body awareness and spatial concepts, which are necessary for safe, efficient and independent movement through the environment. However, a VI may diminish the ability

to use visual information to check the accuracy of movements (Toole et al., 1984). Although students with multiple disabilities may often be responsive to music, they often have mobility limitations and difficulty with change (Piaget, 1952). These students need a learning environment with a variety of communication systems (e.g., picture, tactile and object symbols). Research-based strategies (e.g., repetition and consistent cues) which have been successfully used with students with multiple disabilities often incorporate verbal and physical prompting (Erin, 2017). Erin explained that routine provides a sense of control and students with disabilities usually feel “comfortable when they anticipate events” (p. 331). Music has also been found to help students learn (Sarcomo and Soto, 2012). Other related research includes Sapp (2011) who recommended structured music activities for teaching O&M skills, Molloy-Daugherty (2013), and Barney and Prusak (2015) who observed that children were more active and likely to enjoy participating in activities when there was music playing.

Structured movement routines (SMR) are routines that are made of a series of movements and/or poses. An SMR can allow for the integration of music, communication systems, prompting and movement. When all the strategies are integrated and embedded into individually designed SMR, students are more likely to anticipate movement and connect language to corresponding body and spatial concepts. Sequenced yoga sessions that have a predetermined set of poses in a specific order can be considered types of SMR. In this regard, Bonney et al. (2017) have indicated that the best way to enhance transfer and retention of learning is to train learners using a variable practice structure rather than a repetitive practice.

The idea of developing this app was motivated by the need to help professionals design SMR for their students with VIs and additional disabilities. Research shows that when assistive technology (AT) is used with students with disabilities, the AT promotes attentiveness by allowing for differentiated instruction. The ATs are also less stigmatizing than other types of intervention (Doenyas et al., 2014; Kagohara, 2011). Valentino-Devries (2010) also observed that principles of Universal Design for Learning are incorporated into the use of the iPad. Therefore, iPads are increasingly being used by special educators (Herbert, 2010). Nonetheless, there is still no app available that is specifically designed to support the learning of body awareness and spatial concepts by children who have VI and additional disabilities. Therefore, a multi-disciplinary team has been designing, developing, and testing an app called Body Awareness through Music and Movement (BAMM) to help children with VI

and additional disabilities improve in body awareness and spatial concepts.

Purpose

The purpose of this paper is to report a case study of a design-based research (DBR) effort to create an app that supports understanding of body awareness for children with VI and additional disabilities.

Research questions

The following research questions guided the progress of this study:

RQ1. Is it feasible to design an app with features that facilitate the use of SMR by itinerant professionals?

RQ2. Can BAMM, embedded with features grounded in SMR theory and delivered within a well-designed user interface of a musical app effectively enhance body awareness of children who have VI and additional disabilities in the itinerant model?

Method

Research design

A DBR was used in this study. Wang and Hannafin (2005) define DBR as a “flexible methodology that focusses on improving educational practices through iterative analysis, design, development and implementation based on collaboration among researchers and practitioners in real world settings” (p. 6). Additionally, Stokes (1997) and Schoenfeld (1999) observed that DBR allows educational researchers to study theory and application. In DBR, an intervention is designed, based on current theory to solve actual user problems. The intervention is put into practice leading to new or revised theories that generate more effective interventions and/or new applications. Smith et al. (2013) argued that the design of practical and implementable special education interventions can be improved by DBR. BAMM team’s goal was not only to design an app but to advance the theory that body awareness can be supported by SMR in the student’s natural setting.

There are different ways to conduct DBR, and the BAMM study followed McKenney and Reeves’ (2012) model. The team comprised professionals with expertise in different areas, with the lead researcher being an itinerant certified O&M specialist (COMS). Other team members were: an itinerant teacher of

students with visual impairments, a music therapist and a researcher with experience in working with children with VI and additional disabilities, an autism specialist, a children's dance instructor and a physical fitness expert, a designer for children's art and a software developer. It was imperative that the app be developed using the universal design for learning. It needed to be engaging and inclusive of all students.

Materials, structure and acts of the app

BAMM's design proceeded through cycles of three phases: analysis and exploration, design and construction and evaluation and reflection. The initial analysis focused on establishing the content and features of the app. Guided by the principles of universal design for learning, the app would provide a selection of "acts," each one a combination of a song and movements synchronized to the lyrics of the song.

A board certified music therapist composed a specific song for each act. Text moved to introduction as advised. To create the music for each act, the music therapist chose specific words, composed specific lyrics and used elements of melody, harmony and rhythm to musically facilitate the targeted movement in each act. The lyrics contained language that would reinforce body and spatial awareness (e.g. "hands together, palms touching, in the center"). The instrumental aspects of the music reflected the targeted movement in terms of timing, force and size.

An individualized student playlist was created by selecting appropriate acts from the variety of movements incorporated in standing, prone, supine and seated positions. The ultimate goal was for the app to consist of acts with a range of complexity of movement and language. The initial prototype would consist of simple movement and language.

The idea of designing an engaging character was informed by the need for a model for the movements. The BAMM team thought that the students with residual vision would be attracted to an engaging character that would model movements on the app. After several trials, the final design of the demo character named "BAMMboo" was adopted. BAMMboo is blue, gender neutral, wears a yellow orange top, bright red pants and purple shoes and is visible in the playlist editor shown in Figure 1. The colors selection was based on the fact that children with cortical visual impairments which accounts for 30–40% of VI in children in the USA (Roman-Lantzy's, 2007) prefer brightly colored objects (Good et al., 1994). The app would provide suggestions for object symbols. These symbols are often a way to communicate with students regarding their preferences about the order of the movements.

The requirements for the interface included: simple and intuitive creation and editing of individual playlists, the ability to select a picture from the iPad library or take a picture of individual object symbols that would appear beneath the corresponding act within each playlist, the ability to stop and resume playing acts by tapping anywhere on the screen, playlists created by arranging icons that depict starting position or representative pose of each act, uncluttered and visually stimulating screens, the ability to speed up and slow down acts as appropriate and the ability to name playlists and insert photo of choice within playlists icon (see Fig. 1).

Design and construction—designing the prototype

A simple reaching movement was adopted from the book "teaching Age-Appropriate Purposeful Skills" (TAPS, 2012) and the factors necessary to develop the act agreed on (e.g. the software used to create the music had to be compatible with the standard audio formats available for iOS). The artist had to have a clear understanding of the movements and the key positions to draw, and for accuracy, movements had to be modeled in three dimensions. Approximately 60 movements of various levels of complexity and in a variety of positions were modeled. This would be the BAMM video library from which all movements of the acts would be selected. All the movements consisted of motions typically used in daily living and did not require above average range of motion, strength or endurance. Through collaboration, trial and error, the first act "In the Center," a "tune in" act (Maloney, 2016) was designed.

In total, 12 simple movements including, "In the Center" were selected from the video library for use in the first set of acts that would be included in the first prototype of the app (see Table 1). Each movement has a description, functional purpose, concepts emphasized, possible vocabulary and actual vocabulary. Each act had a number and a corresponding video number. "In the Center" was the first act and the relaxation act (Maloney, 2016) was next on the priority list. The remaining 10 acts were randomly sequenced so that team members could be sure to simultaneously work on the same one. Each time an act was selected to be in a student's playlist, the instructor would have the opportunity to select a picture of an object or tactile symbol from the iPad's album or to take a picture with the iPad's camera. When the playlist was used, that picture would appear below the symbol. DBR allows repetition of steps both within and between each phase. Review and revision

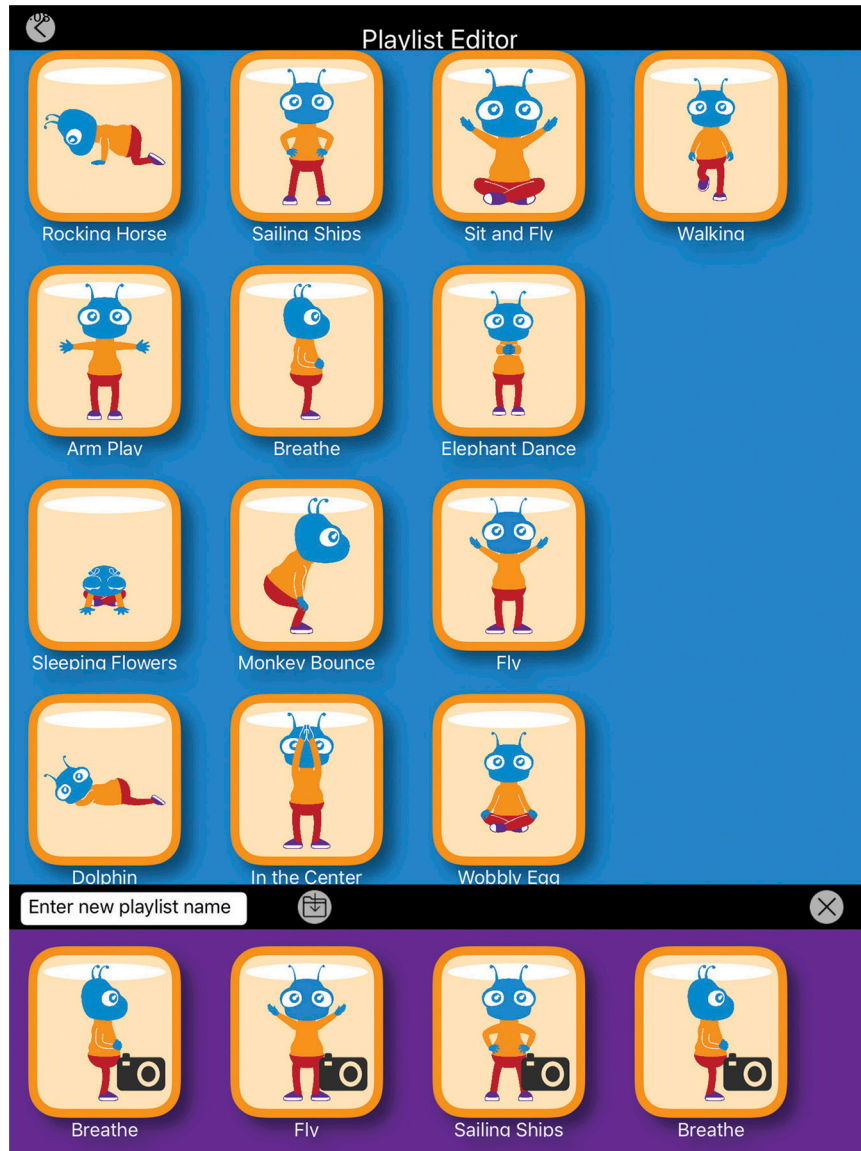


Figure 1: Screenshot of BMM Playlist Editor.

would occur within each phase before proceeding to the next phase (see Fig. 1). Each iteration of the app would be an outcome of one circle.

It was the goal of the team to have a simple prototype completed for expert review at the 2013 Association of the Education and Rehabilitation of the blind (AER) International conference. BMM was accepted for presentation at the conference. However, as the conference date approached, it was clear all the acts would not be complete. The team decided to concentrate on the tuning in act (In the Center), the relaxation act (breath) and three other acts in the list. Many of the features on the user interface were not functional yet, but there was enough information

within the five acts for attendees to provide input on. The researchers would use the survey conducted by the conference sponsors as a review for BMM.

Participant

In the meantime, the lead researcher identified a student as a potential study participant. Joe (pseudonym) was a six year old male with congenital blindness and severe intellectual disability including DeafBlindness. While an optimal pregnancy is 40 weeks gestation, records showed that Joe was born preterm, at 28 weeks gestation. He also used a hearing aid. At the time of this study, Joe was receiving special education

Table 1. Sample of Conceptualization of Acts for Prototype from Video Library.

Name acts.ppt slide no. MOV no.	Description	Functional purpose	Concepts emphasized	Possible vocabulary (suggestions)	Actual vocabulary
In the center 1. no. MOV	Begin-palms together, arms up, Circle down, palms together	Opening act: balance, centering, readying, coordination at midline and laterally	Beginning and ending, breathing	Hands, palms, begin, center, arms, head, overhead, sides, palms, thighs, around, up, arms down, end	Hands, palms, begin center, arms, overhead, around, up, arms up, arms down, end
Fly 8 no. MOV	Startarms out stretched; raise and lower to music	Reaching literally at various heights in search of objects, balance and coordination; moving arms simultaneously	High; low; reaching; up; down; sides; wings; flying	Arms; arms out; straight to each side; low; high; arms down; arms up; low; high; shoulder height	Arms; arms out; straight to each side; low; high; arms down; arms up; low; high
Sailing ships530	Hands on hips; alternate bending and straightening left and right knee. Alternate shifting weight left and right	Components of walking; Alternating sides	Knees; bending; hips; weight; shifting	Hands; hips; knee; right; left; right knee; left knee; straight knees; shift right; shift left	Hands; hips; knee; right; leftright knee; left knee; straight knees; shift right; shift left
Monkey bounce367	Hands on hips; bend and straighten both knees simultaneously; small motion; feet close and feet wide	Transitioning from sitting to standing and visa-versa	Slow; fast; simultaneous; together; close feet; wide stance	Straight bend; knees; hands on hips; bounce; up; down; stop; hands; faster; monkey; stop; done; wider; closer; feet	Straight bend; knees; hands on thighs; bounce; bouncing, up; down; stop; hands; faster; monkey; stop; done; wider; closer; feet

services in life skills classroom. According to his parents, Joe had developed the gross motor skills for walking but had skipped the crawling stage and this seemed to make the transitional movements very difficult for him. Joe had no speech and was not using any AT for communication. He demonstrated alertness by remaining very still (e.g. if someone called out his name). Joe also exhibited self-stimulatory behaviors (e.g. rubbing and hitting his face). Upon consultation the members of Joe's educational team agreed that he could benefit from moderate physical support to transition from sitting on the floor to standing.

The lead researcher had already been working with Joe on O&M skills in his home and on his campus for over six months. Joe and his family trusted

the COMS, who explained what an SMR was to Joe's parents. The parents understood and agreed with the purpose of BAMB, and hoped to reinforce the skills Joe learned by using it in the home. They signed a consent form as a demonstration of their willingness to allow Joe to participate in the study. There was not coercion involved.

Study procedure

An SMR supported by BAMB would be implemented with Joe. Five acts with slower tempos (80–145 beats/minute) were selected and sequenced starting with a "tuning in" song and ending with a "relaxation" song. An object symbol was chosen for each act and

positioned on a chair to the left of Joe while a “finish” basket was positioned to his right on the floor. The routine for Joe involved: unrolling the yoga mat and sitting on it, removing his shoes and socks and placing them to his right, tapping bare feet to feel the yoga mat, transitioning to standing with moderate support and reaching out with his left hand to obtain the object symbol. The object symbols included bumpy balls and fans that provided some sensory input and could remain in contact with his body during the entire movement. All the steps were completed with necessary level of physical support and Joe’s affect was continuously monitored for signs of pleasure or stress. If Joe showed signs of distress, the session would be terminated.

Results

Feedback from the conference participants

Out of the 23 respondents, 87% rated the session as “good” or “excellent,” 90% of the responses were positive and 50% believed that BAMB incorporates features that support research-based practice. Some of the comments captured include: “I was very impressed with the strategies and will implement them in my routines,” “I love the link between music and movement,” and “Good idea for practitioners with MIVI students.” Concerns were raised about the price and the potential misuse of the app. One attendee asked, “What about working in a child’s natural environment [...] doing their own movements? Other participants also gave the following recommendations: “replace terms like pencil and dinosaur with words that are more meaningful to students with MIVI,” and “showing videos of the app being used by children and translating the lyrics into other languages.”

Joe

After two months of one/two sessions per week, Joe independently initiated a movement for the first time. On hearing the first note of the “elephant dance” act, he reached with his left hand and grasped the object symbol (bumpy ball), held it with both hands, arms straight down and proceeded to independently bend forward from the waist (the starting position for the act). Through this multi-sensory approach with consistency and repetition, Joe anticipated the next song and initiated the first movement. By this time, Joe’s ability to transition to standing improved. He independently turned his torso to put his hands on the chair he used for support, and only required phys-

ical cues instead of moderate physical support for some portions of the transition. He engaged in the BAMB routine for the remainder of the school year, another four weeks. During this time, he began to independently put his palms together for the first act. The next school year, Joe went to a different school and no longer had the same COMS. BAMB was not yet available for download so his routine could not continue with consistency.

Discussion and future research

The purpose of the case study effort was to determine whether an app embedded with features grounded in SMR theory and delivered within the user interface of a musical app, can enhance body awareness for students with VI and additional disabilities. Preliminary feedback from professionals in the field has been promising as demonstrated by the responses from the AER conference participants. Similarly, the effectiveness of the app has been demonstrated by one participant who had multiple disabilities. The participant was able to initiate a movement after several trial instructions with the app. This result seems to support the findings by Sigafoos et al. (2007) and Nikopoulos and Keenan (2004) that video modeling was a successful teaching tool for improving self-regulation in children with autism. Considering these results, the researchers plan on testing the prototype using single subject research design (SSRD) with multiple participants (multiple baseline design across participants). In this design each participant acts as own experimental control (Horner et al., 2005). SSRD also allows within-case comparisons, therefore it will be possible to compare the performance of each participant before and after the intervention.

The main limitation of this study was the use of a single participant. However, future studies are underway in which a larger cohort will be assessed. The planned study will involve collecting baseline data to establish the functional level (Price et al., 2015) of each participant in different body awareness areas prior to the implementation of intervention.

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