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The use of assistive technology in classroom activities for learners with motor impairments at a special school in South Africa

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ABSTRACT

Introduction: *Participation in education is the right of every child, regardless of disability. An Assistive Technology and Inclusion Programme, implemented at a special school, has provided learners with motor impairments with an alternative to typical writing and other classroom activities in which they cannot participate. This study aimed to describe how learners with motor impairments use assistive technology to participate in classroom activities at a special school in South Africa.*
Methods: *A quantitative, descriptive study was conducted with 34 learners enrolled in this programme. The children were observed performing a pre-determined activity using assistive technology. An observational checklist was compiled from the literature and relevant school activities. Video recordings of each learner's performance were used to score the checklist.*
Results*: Activity performance was assessed according to the learner's ability to use assistive technology, their need for assistance, quality of performance and speed of performance. Most learners were able to perform all the activities with some verbal and physical assistance, cutting and erasing required the most assistance but the ability to use the assistive technology (>90%) and quality of performance (>85%) achieved high scores. The median time to complete the activity varied from 5 to 66 seconds.*
Conclusion: *This study yielded descriptive evidence on learners with motor impairments' successful use of assistive technology when participating in school activities, and reinforced the importance of an occupational therapy Assistive Technology and Inclusion Programme in the classroom. Further context-based evidence is required to improve the expansion and sustainability of such programmes.*

Key words: Occupational therapy; assistive technology; motor impairments; school activities; participation; South African special schools

INTRODUCTION

"For most people, technology makes things easier. For people with disabilities, technology makes things possible"[1:9]. Assistive technology is regarded as an umbrella term for a broad range of devices, services (such as educational or rehabilitation) and practices applied to address the difficulties faced by individuals with a disability[2]. The internationally accepted definition of assistive technology refers to any item, piece of equipment or product system, whether acquired commercially off the shelf, modified or customised, that is used to increase, maintain or improve functional capabilities of individuals with disabilities[1], or to prevent impairments, activity limitations or participation restrictions[2]. Assistive technology in support of education may, for example, enable a child with cerebral palsy (who has extreme motor control problems and is unable to adequately hold a pencil), to participate in a classroom writing activity by using equipment such as an enlarged keyboard, adapted mouse and specific computer software[3,4]. The use of assistive technology as an alternative strategy to enable children to engage in typical activities can serve as a powerful enabler of participation[5,6].

In the past few years, major growth in assistive technology production, application and use in society has been observed, also in the domain of persons with disabilities[2,7,8]. This occurred not only due to technological advancements, but also as a result of legislation supporting the rights of people with disabilities[8,9]. Access to and use of affordable assistive technology is a human right endorsed by prominent guiding documents, such as the Convention on the Rights of Persons with Disabilities[9], the World Report on Disability[10], the Global Disability Action Plan 2014–2021[11] and Sustainable Development Goals 2030[12]. Therefore, children with disabilities are entitled to available and affordable assistive technology[1].

Furthermore, various governing bodies declared that education was a basic right of every child[13]. Inclusive education advocates for the right of all children, regardless of disability, to access schooling[14,15]. In certain countries, the right to inclusive education of learners with motor impairments is accommodated by the full implementation of policies, which ensures that they receive reasonable support, adaptations in their classroom, and all necessary assistive technology to participate in school activities[16].

However, in South Africa (which has many resource-limited educational environments), the gap between inclusive education policies and their implementation means many learners with motor impairments do not have access to assistive technology and opportunities to participate in regular school activities[17]. Consequently, the occupation of education, which comprises activities or tasks that are essential for learning and participating in the educational environment[18], is compromised for learners with disabilities in South Africa, often resulting in occupational injustice. Hence, there is a call for all stakeholders in South Africa to improve access to assistive technology by developing national plans, policies and programmes supporting the education of children with disabilities[1]. The purpose of assistive technology is to bridge the disparity between the disabled learner, the classroom activity and the educational setting[19]. With the use of assistive technology, learners with motor impairments are better equipped to participate in basic classroom activities, thereby promoting further development of curriculum skills and allowing education to have a more valuable impact on the lives of these learners [5 April 2017; personal interview; H Vermeulen, Director: Khanya for Life].

This study was completed at Tswellang Special School in Bloemfontein where children present with motor impairments and display limited engagement in the occupation of education, as they cannot follow a typical school curriculum or function independently without assistance or adaptations within a regular school[6,20]. Participation in classroom activities, such as writing, drawing and copying from the board, is negatively influenced by these learners' poor motor control caused by various physical disabilities. This lack of participation affects their learning and holistic development. In this context, the role of the occupational therapist is vital in adapting the environment for these learners and providing them with alternative methods (through the use of assistive technology), to enable participation in regular classroom activities[21].

The school responded to the call to improve access to assistive technology (despite limited funds and lack of government support for equipment) by initiating an Assistive Technology and Inclusion Programme, supported by Khanya for Life, a non-profit, community-based organisation. This programme was developed by an occupational therapist, who endeavoured to limit occupational injustice and improve the participation of learners with severe motor impairments in everyday classroom activities, by promoting and facilitating access to assistive technology [5 April 2017; personal interview; H Vermeulen, Director: Khanya for Life].

In order to establish the best learner-technology fit to enable participation, the occupational therapist had to take into account the learners, the specific classroom activity, appropriate technology and the environment[2].

Although the Assistive Technology and Inclusion Programme at Tswellang has proven to be very successful from a clinical perspective by improving learners' ability to participate more independently in school activities and meeting the individual learner's needs through consideration of the Human, Activity, Assistive Technology (HAAT)[2], no empirical studies have been done to document how learners use assistive technology to participate in their classroom activities, or on the impact of the programme at this specific school. Furthermore, limited information is available on the use and impact of assistive technology for learners with motor impairments to participate in school activities in South Africa. Consequently, there is no evidence to guide practice, policymakers, stakeholders and funders towards ensuring the sustainability and further development of similar programmes across South Africa to ultimately promote the human rights of each child. The aim of the study reported here was to describe how learners with motor impairments used assistive technology when participating in classroom activities at a special school in Bloemfontein.

LITERATURE REVIEW

All children have the right to education[13], even those who cannot follow a typical school curriculum and/or function independently within a regular school setting. According to guiding documents, such as the Department of Basic Education's White Paper Six[22] and Screening Identification Assessment and Support[14], a child with barriers to learning has the right to inclusive education. Inclusive education specifies that all children are able to learn and their educational needs should be met by addressing attitudes, teaching methods and curricula[20].

However, children with physical disabilities (such as cerebral palsy and amputations) experience barriers in accessing and participating in the occupation of education[23,24]. Access to education for physically disabled learners is limited by external barriers to learning, such as gaining admission to regular schools, poverty, lack of resources and assistive technology, inaccessible transport and limited government funding[1,25]. Furthermore, educating learners with motor impairments places heavy demands on services and requires specialist skills, which may result in hesitancy from schools when considering learners' admission[26]. Consequently, many children with motor impairments are not afforded the opportunity to attend schools[27,28]. Only ten percent of children with disabilities in South Africa attend school and are mostly accommodated in special schools, while others are placed in disability care centres or left at home[29]. Children with motor impairments may battle with school activities that involve purposeful sensory experiences[30,31] and social communication difficulties. [5 April 2017; personal interview; H Vermeulen, Director: Khanya for Life]. Hence, appropriate special education services that "can provide children with disabilities with maximum access to the classroom and enable them to take part in regular schooling more effectively"[32:44] are necessary. In order to achieve this, inclusive education policies that are globally recognised as a key factor in providing education to all (including children with motor impairments)[16], are implemented to enable optimal participation by such learners[32,33].

While inclusive education policies have been successfully implemented in some countries, this is not the reality in South Africa[34]. Although a commitment to inclusive education is demonstrated at a national, legislative and policy level in South Africa[35], the gap between policy development and the implementation thereof remains problematic, even years after the publication of policies such as the Salamanca Statement and White Paper Six on Special Needs Education[17].

Although most schools in South Africa are not appropriately equipped to support children with motor impairments, special schools are appointed to deliver education to learners requiring high-intensity educational support[35,36]. In South Africa, there are 380 special schools with approximately 46 600 learners. In the Free State Province, 3 127 learners are accommodated in 19 special schools, of which four are located in Bloemfontein[36].

However, apart from supporting a child with motor impairments within the inclusive and/or special educational setting, other environmental adaptations, additional equipment, and supportive assistive technology are required. Although these schools are government-funded, the budgets are limited and schools also depend on external private funds and fundraising events to provide extras such as assistive technology.

Assistive technology comprises special devices or structural changes that can increase, maintain or improve the functional abilities of individuals[2]. It can promote the individual's ability to make independent choices, which facilitates engagement in play, movement, communication and participation in various contexts and environments[37]. Furthermore, it can improve learning capabilities, independence and the learner's self-esteem[38], while also allowing the user to demonstrate agency, express basic needs wilfully and show self-determination. Simultaneously, assistive technology provides opportunities for the users to show aspects of their personality that were previously concealed, and additionally facilitates engagement in activities that add value to users' lives[1,20]. Therefore, it can be argued that the role of assistive technology is vital to facilitate inclusive education and bridge the gap between the typical and disabled child within the education setting. Although all children should have access to affordable assistive technology[1] only 5–15% of children in low-income settings receive the assistive technology they require[39,40]. Of those, a third of assistive devices are abandoned as a result of an inappropriate match between assistive technology and the user. Furthermore, young children quickly outgrow their assistive devices requiring the constant evaluation and supply of updated devices[1,19].

Various types of high-tech assistive technology are available for use by for learners with motor impairments, including gaze-based assistive technology[20,41], cross scanners[42], joysticks, arrows and pointing devices, chorded keyboards, algorithms and filtering mechanisms, and speech-and-gesture recognition software[43]. Low-tech assistive technology includes protective headgear, pressure relief cushions, ramps and handle-bars, hearing aids, communication boards and splints[1].

To guide the appropriate selection and provision of assistive technology, the discussion paper released by the World Health Organization (WHO)[1], Assistive Technology for Children with Disabilities: Creating Opportunities for Education, Inclusion and Participation, postulates six principles: (i) availability (providing products in sufficient quantity and as close as possible to children's community); (ii) accessibility (providing products to every child who requires it regardless of social group, gender, disability or geographic region); (iii) affordability (providing products to the family of all those who require it through subsidies); (iv) adaptability (adapt services and products to ensure they meet the individual's need); (v) acceptability (involving the user and their families in the process of selecting the device in order to consider their needs and preferences); and (vi) quality (all products and services are of appropriate quality in terms of its strength, durability, capacity, safety and comfort)[1].

In order to follow these principles and prescribe the appropriate assistive technology, a comprehensive assessment of children who qualify for assistive technology, is essential. Occupational therapists and other health- and educational professionals involved should be cognisant of the appropriate assessment process before prescribing assistive devices and training the child in the use thereof. The selection of assistive technology for children in South Africa is a complex process. The availability of financial resources (especially in resource-limited environments) and formalised support (such as supervision of the programme) are only two of the factors to consider when providing appropriate assistive technology[41]. The selection of appropriate assistive technology requires the consideration of relevant theories and models[6,44] and familiarity with the assistive technology spectrum[19].

To establish the best learner-technology fit to enable participation, occupational therapists use the Human Activity Assistive Technology (HAAT) model as the theoretical framework for the clinical reasoning process[2,23,45].

The HAAT model allows the therapist to deliberate the human (i.e. learner with motor impairments), activity (i.e. classroom activities such as cutting) and assistive technology (i.e. adapted keyboard, joystick) components that might best assist the learner to participate within the environment (school context), in order to establish the best learner-and-technology match[2]. After completion of the assessment process, the implementation phase should be monitored and evaluated. Evaluation of the continual impact of the assistive technology should be done by means of existing outcome measures[19,46-49] and a programme development process[50].

Two outcome measures that evaluate the impact of the assistive technology in the classroom are described in the literature. The School Setting Interview (an assessment of the student-environment fit) for learners with physical disabilities explores 14 activity items, such as writing, reading, doing maths, getting around the classroom, taking examinations and interacting with staff[27] and the School Function assessment that assesses participation, task support and activity performance[46]. However, these outcome measures are not appropriate to evaluate the participation of learners with motor impairments during classroom activities which require the use assistive technology in a resource-limited environment.

The programme developmental process, as described by Dudley[50], is also used for evaluation purposes and to generate programme evidence as this can "inform judgements on whether a proposed programme should be started, how well an existing programme is functioning, or whether an established programme is achieving the desired effects"[50:1]. This process involves eight steps, some of which were addressed in this study namely, (Step 1) to engage stakeholders (interview with programme developer and staff at Tswellang Special School); (Step 2) establishing what is known through an extensive literature review; (Step 3) describing the specific programme by selecting a study design; (Step 4); and (Step 5) defining the indicators. These steps should be followed when performing research, and to establish clinical evidence to guide future intervention planning[19].

METHODOLOGY

Study design

A quantitative, descriptive study design, using an observational checklist, was implemented in this study.

Population and sampling

Tswellang Special School is an Sotho and English-medium school and has 288 learners enrolled in a mainstream or an adapted curriculum, of which 183 learners have a diagnosis of cerebral palsy [5 April 2017; personal interview; H Vermeulen, Director: Khanya for Life]. The remaining children have other motor impairments such as muscular dystrophy, traumatic brain injuries and physical birth defects. Learners from Tswellang Special School are mainly Sesotho-speaking and generally come from a low socio-economic background. The population for the study consisted of 40 learners with severe motor impairments who are unable to participate in classroom activities without additional support. The learners ranged from Grade 1 to Grade 9 in three different classes (mainstream curriculum, adapted curriculum and learner support services).

A total population sampling of all learners already in the Assistive Technology and Inclusion Programme who met the inclusion criteria, were included in the study. Learners were included if they presented with a motor impairment (irrespective of comorbid conditions such as epilepsy and visual impairment), had been enrolled (identified for the programme, assessed and received occupational therapy intervention) in the Assistive Technology and Inclusion Programme for more than six months, and had access to their own assistive technology in class. Of the 40 learners who met the inclusion criteria, six learners were absent on the day of the research execution.

Measuring instrument

The measuring instrument used in this study consisted of two sections:

Section 1: Completion of a demographic questionnaire (age, gender, language, pathology, level of education, the period of time using assistive technology and a description of seating and positioning for computer access). The participants' Gross Motor Functioning Classification System (GMFCS) level and the Manual Ability Classification System (MACS) level were also recorded. The GMFCS and MACS consist of five levels that describe the gross motor functioning and fine motor functioning of the individual. Level one is the most functional and level five the least functional[51,52].

Section 2: The researchers developed a non-standardised School Activity Participation Checklist for this study, based on instrument development theory[53,54], the informal assessment instrument created by the programme coordinator to identify and assess learners who benefit from the assistive technology programme, relevant literature such as the HAAT Model[2], the School Setting Interview[27], the School Function assessment[46], the use of activity analysis[55], and appropriate classroom activities used at Tswellang Special School.

The School Activity Participation Checklist included the participation of learners in specific activity areas in which they experienced difficulties, such as classroom activities (cutting, pasting, colouring, drawing and erasing), manipulation activities (taking out a pen, opening and paging through books) and copying activities (copying from the board or a book). Also included in the checklist was the type of assistive technology used by the specific learner and the body parts/areas used to make use of the assistive technology. The learners' ability to use the assistive technology, the quality of the end-product they produced and any physical or verbal assistance required by the learner, were scored as either 'yes' or 'no' (not describing the level of assistance the learners needed). The time required to perform the activity was recorded in seconds. A 'comment' section was also included in the checklist to record any observations pertaining to mental and/or physical effort and compensations made by the learners during activity participation.

The specific assessment activity used in the study

A pre-determined computer-based activity was designed by the researchers (Figure 1) to be inclusive of general classroom activities appropriate for Grade 1 to Grade 9 learners (Table I page 15).

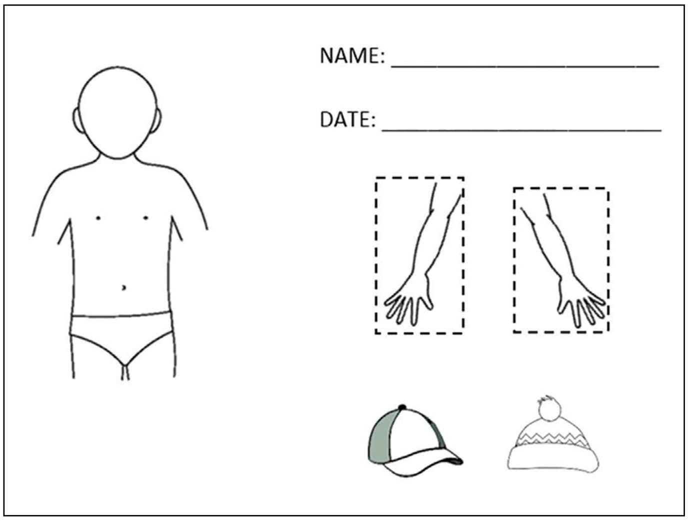

Figure 1. Electronic classroom activity performed by learners by means of assistive technology

The learners in the study sample were provided with a landscape A4-page on the Paint programme on their computers. The learners in the study sample were instructed to page through the documents on the computer, find the correct document, open the document, and choose the assessment activity sheet. The learners proceeded to type their names, copy the date from the blackboard at the front of the class, cut the arms, paste it to the man, choose one of the two hats, put one hat on the man's head and erase the other hat. Finally, the learners were tasked with drawing the legs, colouring the swimwear and saving the document.

Table I. Classroom activities performed and steps involved

Activity	Steps involved
Opening books and paging	Locate and click on the document; double-click on the mouse to select the first page; click on the right arrow to move to the next page; and open the third page in Paint.
Taking out pen/pencil	Either insert textbox or select writing tool by locating these functions on the menu and then clicking on them; position correctly on document by clicking and dragging the box.
Composition of written material	Use mouse to click on the textbox and keyboard to type and formulate name.
Copying from the blackboard	Look at the board and copy the date from the blackboard using above-mentioned writing method.
Cutting	Locate 'select' option on menu; choose type of cutting option (free-hand or box); position cursor in relation to object needing to be cut; left-click-hold-drag the mouse over the desired object; release mouse.
Pasting	Left-click and hold cursor over cut image then drag to desired position; release mouse.
Erasing	Locate and select erasing tool on tab; move cursor towards item to be erased; left-click-hold-drag the eraser over the image until completely erased.
Drawing	Locate and select desired method of drawing (shapes, pencil, line); move cursor to desired area on document; left-click-hold-drag cursor to draw legs.
Colouring	Locate and select method of colouring on tab; move cursor to desired colouring area on document; left-click to colour desired area.

Data collection

A pilot study was conducted on five randomly selected Grade 3 learners from the study sample at Tswellang Special School. The outcomes of the pilot study indicated that minor changes needed to be made to the School Activity Participation Checklist, which included formatting of the tables, recording of the speed in seconds instead of minutes, adjusting the steps involved when completing classroom activities, adding 'adapted curriculum' into the demographic section, adding a column for comments when describing the assistance provided as well as removing the activity of 'taking out books'. Only minor changes made to the checklist, and therefore the results of the pilot study learners were included in the main study.

Five final-year occupational therapy student researchers completed the demographic questionnaires at Tswellang Special School, prior to the observation session in the class based on information from learners' school file and their teacher/s. Two therapists working at the school confirmed each learner's demographic information to ensure accuracy. The educators and occupational therapist at Tswellang Special School worked together with the researchers to set up the necessary equipment and materials required for data collection in the classrooms. The observations were done in the learners' assigned classrooms, among their classmates and the class teachers for accurate data collection. Each learner's observations were individually videotaped for later analysis. Although each classroom was structured differently, the researchers ensured that each child's table and assistive technology were correctly structured to participate. When necessary, the teachers assisted to overcome the language barrier by translating some of the instructions.

During the assessment activity, physical and verbal assistance were provided and recorded by the researchers where appropriate. Each observation session took approximately one hour to complete. Scoring of the School Activity Participation Checklist then took place after school hours by the same researcher who assisted the participating learner. The checklists were later verified by another two researchers to prevent possible clerical errors. In the event of different scores, the video footage and the two checklists most similar to one another were used.

Data analysis

Descriptive statistics, namely frequencies and percentages for categorical data, and medians and percentiles for numerical data, were calculated. The analysis was performed by the Department of Biostatistics, University of the Free State.

Ethical considerations

Approval for this study was obtained from the Health Science Research Ethics Committee of the Faculty of Health Sciences, University of the Free State (reference number UFS-HSD2018/0137/ 1906). Written permission was granted by the Free State Department of Basic Education and the principal and class teachers at Tswellang Special School. Additionally, informed consent and permission to use demographic information and video recordings was obtained from all the guardians/ parents of the participating learners and the learners provided verbal assent to participate prior to the study. Confidentiality with regard to names and scores was maintained throughout the research process.

RESULTS AND DISCUSSION

Demographic variables

Thirty-four Sesotho-speaking learners from Grade 1 to Grade 9 in both mainstream and multi-level classes met the inclusion criteria to participate in the study. Nineteen (55.9%) of the learners were male. The median age was 13.1 years, ranging from seven to 18 years of age. All the participants had been enrolled in the Assistive Technology and Inclusion Programme for a minimum of six months, with three-and-a-half-years being the median period of time the learners were enrolled in the programme. With regard to seating and positioning, 15 (44.1%) learners used wheelchairs, while the remainder needed no adjustments or mobility devices. Table II (page 16) summarises the pathologies observed in this group of learners and how many learners per grade participated. The majority of learners (n=12; 35.3%) presented with athetosis, followed by quadriplegia (n=4; 11.8%).

Pathology

A large portion of the study sample population presented with

Table II. Pathologies that learners (n=34) in the Assistive Technology and Inclusion Programme presented with and school grades in which they were enrolled

	n (%)
Pathology	
Athetosis	12 (35.3)
Quadriplegia	4 (11.8)
Ataxia	3 (8.8)
Triplegia	2 (5.9)
Amputation	2 (5.9)
Arthrogryposis	2 (5.9)
Congenital deformities	2 (5.9)
Spinal muscle atrophy	2 (5.9)
Arthritis	1 (2.9)
Mixed cerebral palsy	1 (2.9)
Muscular dystrophy	1 (2.9)
Phocomelia	1 (2.9)
Diabetes	1 (2.9)
Grade	
Grade 1	1 (2.9)
Grade 2	3 (8.8)
Grade 3	5 (14.7)
Grade 4	4 (11.8)
Grade 5	1 (2.9)
Grade 6	4 (11.8)
Grade 7	1 (2.9)
Grade 8	4 (11.8)
Grade 9	2 (5.9)
LSS* classes	9 (26.5)

*LSS = learning support services

athetosis, making it possible to make collective data observations. Regarding the pathology of the learner and type of assistive technology, it was noted that seven (58.3%) of the 12 learners with athetosis used additional assistive technology. In contrast, the remaining portion of the sample showed a large variety of pathologies, limiting the ability to observe any potential influence of pathology on the type of assistive technology used, the quality of end-products or the ability of the learners to participate.

The paucity in sound epidemiological information of children with disability in South Africa leads to the lack of sound prevalence of children with motor impairments to compare this study population against[56]. What is known (and also reflected in the participants in this study) is that cerebral palsy is the leading cause of physical disability in children worldwide with a high prevalence of up to 10 cases for every 1000 live births in South Africa[57].

Learners' gross motor (GMFCS) and fine motor (MACS) levels

Table III (on this page) shows the distribution of the learners' GMFCS and MACS levels. Ten (29.4%) learners were classified as levels 1 and 4 on the GMFCS, indicating that the same number of learners were on a functional or relatively poor functional level for gross motor abilities. Fourteen (41.2%) learners were on MACS level 2 and nine (26.5%) on level 4. Only three (8.8%) learners were on MACS level 1, indicating very good performance of fine motor activities. No definitive trends between the GMFCS and MACS scores regarding the learners' gross and fine motor functional abilities were noted. This corroborates with research that indicate the two tests vary significantly based on subtypes of CP and chronological age of the child[20,58]. The two classifications complement each other and "provide complementary but distinctive information related to mobility and manual abilities of children with CP"[59:276].Therefore, employing both scales is recommended as they each provide different information pertaining to the learner's level of functionionality[60].

Table III Gross Motor Function Classification Scale (GMFCS) and Manual Ability Classification Scale (MACS) of motor-impaired learners (n=34)

Level	GMFCS	MACS
	n (%)	n (%)
1	10 (29.4)	3 (8.8)
2	9 (26.5)	14 (41.2)
3	3 (8.8)	6 (17.7)
4	10 (29.4)	9 (26.5)
5	2 (5.9)	2 (5.9)

It was noted that the learners who had more impaired motor function according to the motor classification scales, required less verbal/physical assistance (from the researchers) to perform activities. This discrepancy could be attributed to the fact that learners classified on higher levels of impaired (on the GMFC and MACS) use a larger number of computer-based assistive devices to complete a school related activity. Similarly, it has been reported that the extent of assistive technology or environmental adaptations required for a child to complete a task, is proportional to the level of impairment experienced by the child[61]. However, ultimately for the children more severely affected by cerebral palsy, the use of more assistive technology might enable/assist the child's participation in activities. The benefit from the appropriate match between the assistive technology, child, activity and context/environment[2,45] outweighs how the equipment might look, as long as it may provide the opportunity to be included in activities with peers[62].

Assistive technology

All learners used a computer with a basic Paint programme as an assistive device to aid completion of activities. In addition to the software, learners used a single device or a combination of assistive technology devices. As shown in Table IV (page 17), 25 (73.5%) learners used a standard mouse, while 19 (n=55.9%) used a standard keyboard.

Learners in this study displayed a wide variety of motor impairments, and therefore innovative methods of manipulating the assistive technology were noted. Twenty-eight (82.4%) learners used their hands and fingers, three (8.8%) used only their fists, two used their forearms (5.9%) and one (2.9%) used his feet and toes.

A variety/group of assistive technology devices, also referred to as 'computer access technologies', which enable children with disabilities (such as cerebral palsy) who cannot use a standard keyboard and mouse, is available. These devices facilitate the use of computers in an alternative way to participate in school activities[6].

Table IV: Type of assistive technology used by motor-impaired learners in the study (n=34)

Keyboards	n (%)	Mouses	n (%)
Standard keyboard	19 (55.9)	Standard mouse	25 (73.5)
Vision board	8 (23.5)	Joystick	1 (2.9)
On-screen keyboard	7 (20.6)	Trackball	4 (11.8)
		Joystick + buddy button	3 (8.8)
		Trackball + buddy button	1 (2.9)

Table V: A description of each learner's (n=34) pathology, GMFCS level, MACS level and assistive technology used

Pathology of learner	GMFCS Level	MACS Level	Assistive technology	
			Keyboard	Mouse
Arthritis	5	5	On-screen keyboard	Trackball
Athetosis	5	4	Vision keyboard	Joystick & Buddy button
Athetosis	4	4	On-screen keyboard	Joystick & Buddy button
Athetosis	2	4	On-screen keyboard	Joystick & Buddy button
Athetosis	2	4	On-screen keyboard	Joystick
Athetosis	4	4	On-screen keyboard	Trackball & Buddy button,
Athetosis	3	3	Vision keyboard	Trackball
Athetosis	2	4	On-screen keyboard	Standard mouse
Congenital deformities	4	3	Vision keyboard,	Trackball
Quadriplegia	4	3	On-screen keyboard	Standard mouse
Ataxia	1	3	Vision keyboard	Standard mouse
Ataxia	3	2	Vision keyboard	Trackball
Quadriplegia	4	2	Vision keyboard	Standard mouse
Amputation	1	3	Vision keyboard	Standard mouse
Phocomelia	1	2	Vision keyboard	Standard mouse
Athetosis	1	2	Standard keyboard	Standard mouse
Athetosis	2	4	Standard keyboard	Standard mouse
Athetosis	2	3	Standard keyboard	Standard mouse
Athetosis	2	4	Standard keyboard	Standard mouse
Athetosis	1	3	Standard keyboard	Standard mouse
Triplegia	2	2	Standard keyboard	Standard mouse
Triplegia	4	2	Standard keyboard.	Standard mouse
Diabetes	1	1	Standard keyboard	Standard mouse
Mixed cerebral palsy	2	2	Standard keyboard	Standard mouse
Muscular dystrophy	1	2	Standard keyboard	Standard mouse
Spinal muscle atrophy	4	1	Standard keyboard	Standard mouse
Amputation	1	5	Standard keyboard	Standard mouse
Congenital deformities	1	2	Standard keyboard	Standard mouse
Arthrogryposis	4	2	Standard keyboard	Standard mouse
Arthrogryposis	1	2	Standard keyboard	Standard mouse
Ataxia	3	4	Standard keyboard	Standard mouse
Quadriplegia	2	3	Standard keyboard	Standard mouse
Quadriplegia	4	2	Standard keyboard	Standard mouse
Spinal muscle atrophy	4	2	Standard keyboard	Standard mouse

Although pointing devices and keyboard modifications improved the participation for children in this study, available studies confirmed that one standard solution cannot be applied to all individuals with CP[43]. Moreover, no other studies describing the use of assistive technology by similar groups of children, to which our results could be compared, could be located in the literature. Furthermore, at the time of the study no comprehensive, large-scale intervention studies of assistive technologies, was available to suggest that one or more assistive technology device could enable access to access to classroom activities for a specific individual[43].

Thus, given the individualised modifications required for each child with his/her motor impairment, this study did neither aim to compare the effectiveness of the various assistive devices with children, or to prove a correlation/association between specific GMFCS/MACS levels and certain assistive technology used by children. Table V (on page 17) was therefore included to provide a simple description of each learner's pathology, GMFCS level, MACS level and the type of assistive technology used to participate in classroom activities.

Performance indicators for the classroom activity:

1. Verbal and physical assistance

For the purpose of this study, verbal assistance refers to any additional or repeated verbal instructions after the first explanation of the activity. Physical assistance refers to the facilitation of any movement required in the activity and positioning of the learner and the body part that will be using the assistive technology.

Verbal assistance was given more frequently than direct physical intervention (Table VI, below), as verbal assistance was deemed the first step in assisting the learners and was followed by physical assistance only if necessary. Verbal instructions were given before using direct physical intervention to allow the learner to have the greatest possible opportunity to perform activities independently[63]. Therefore, assistive technology adds value to the classroom setting by reducing the need for the teacher to provide additional physical assistance to learners using assistive technology.

The activities of cutting and erasing required the most assistance, as these activities, in particular, required the learners to perform complex "click-hold-drag" movement sequences simultaneously with their assistive device to complete the tasks, whereas the other activities did not (Table VI below). This finding is corroborated by other studies where the navigation of a "drag" movement with a mouse seemed complex[42,64].

With cutting, five (14.7%) learners required physical and 14 (41.2%) verbal assistance, while with erasing, three (8.8%) learners required physical and 13 (38.2%) verbal assistance. We observed that performing this complex sequence was influenced by the motor impairments, such as jerky movements and a limited range of movement. Irrespective of the type of cerebral palsy that an individual presented with, if their hand function was affected they required alternative methods of performing activities[24].

2. Ability to use assistive technology

Ability in this study referred to whether or not learners were able to perform and complete activities that required the steps listed in Table I (on page 15).

All the learners were able to complete seven of these nine classroom activities to create an adequate product. With regard to the remaining two activities that involved cutting and erasing, 33 (97.1%) and 31 (91.2%) of the learners, respectively, were able to perform these activities using their assistive technology (Table VI below).

The ability of the learners was influenced by their familiarity with the programme on which the activity was presented. Learners in the senior grades were not skilled in using the various features of the Paint programme. Consequently, their ability to quickly, accurately and effectively perform the desired actions was affected negatively. Some learners did however, show proficiency in adjusting the size of tools to meet their preferences and made innovative adaptations to complete activities. These observations were similar to the findings of other studies where children with a physical disability recognised that assistive technology enabled them to participate independently and facilitated learning[4], emphasising the importance of the fact that a suitable learner-technology match is a powerful enabler of participation[5].

Comments regarding any effort and compensation by the learners that were visible to the researchers were recorded on the checklist. Effort was described as the way in which motivation translated into the learner's work outcomes, with both physical and mental exertion[65]. Trends observed regarding the effort included approaches such as selecting a shape instead of drawing the legs free-hand to reduce the time needed, adjusting the thickness of lines, selecting a different font, adjusting the size of the eraser, adding detail to drawings and making individual colour choices. Limited physical exertion was observed (no sweating or heavy breathing), but academic and mental effort to complete the activities were observed. The mental effort was exhibited by the learners becoming visibly frustrated or irritated when attempting to complete the activities, particularly

Table VI: Motor-impaired learners' (n=34) results for classroom activities

Activity	Assistance needed		Ability to use assistive technology	Quality	Speed* (seconds)	
	Physical	Verbal				
	n (%)	n (%)	n (%)	n (%)	Range	Median
Cutting	5 (14.7)	14 (41.2)	33 (97.1)	29 (85.3)	3–120	22
Pasting	2 (5.9)	6 (17.7)	34 (100)	31 (91.2)	1–183	5
Drawing	1 (2.9)	4 (11.8)	34 (100)	33 (97.1)	10–455	66
Colouring	0 (0)	4 (11.8)	34 (100)	31 (91.2)	3–130	15
Erasing	3 (8.8)	13 (38.2)	31 (91.2)	31 (91.2)	5–260	21
Taking out books	0 (0)	4 (11.8)	34 (100)	34 (100)	1–25	5
Taking out pencil or pen	1 (2.9)	3 (8.8)	34 (100)	34 (100)	1–30	6.5
Copying	1 (2.9)	2 (5.9)	34 (100)	32 (94.1)	4–180	36
Composition of written material	0 (0)	5 (14.7)	34 (100)	33 (97.1)	8–310	29

*Mean speed: data distribution was skewed for the numerical variables because of distribution of data; therefore, the median was used as a summary statistic.

cutting. Noticeable compensations included the use of a single finger to perform keyboard activities because the remaining fingers' movements were jerky and uncoordinated, and also a learner who used their chin to move the joystick to complete the activity effectively.

Quality

The presentation of an end-product, neatness and whether the learner completed the activity correctly were taken into consideration to measure quality. All the learners demonstrated the highest quality (n=34; 100%) for taking out books and taking out a pencil, followed by (n=33; 97.0%) for the composition of written material and drawing. Most learners 29 (85.2%) experienced difficulty with cutting, for which the quality was evaluated as 'inadequate'. This was related to unfamiliarity with the task, poor quality judgement and/or the learner's physical symptoms. The quality of performing a task was also influenced by the tools selected and the learner's attention to detail when completing the activity. It was evident that the learners aspired to create products of a high quality, since they erased and repeated components if they were not satisfied with their performance. This is in agreement with other studies where the use of assistive technology was proven to enable children with physical limitations to provide higher quality end products for schoolwork[4,44].

Speed

Most activities were completed in less than 60 seconds, with the fastest performance observed for pasting, which was completed in a median of 5 seconds (range 1–183 seconds), and taking out books (median 5 seconds; range 1–25 seconds). Drawing, however, took the longest to complete with a median of 66 seconds (range 10–455 seconds). It should be noted that the learners' primary focus was on quality as opposed to speed. Furthermore, the speed of the activities was affected by the learners' choice of drawing tool, as some chose to create intricate drawings of legs while others used simple shapes.

The time taken during composition of written material depended on the different lengths of learners' names, and some also chose to include their surnames. These methods included drawing one's name instead of typing, using a paintbrush or a filter to colour in, adjusting the font type and size when typing, zooming in on the document, different cursor speeds, and the level and amount of attention that certain learners paid to accuracy and detail. Children with physical disabilities generally produce a smaller quantity and poorer quality of work than their peers. Yet, assistive technology such as on-screen keyboards, proved to be faster and more accurate than a keyboard and mouse[43]. Furthermore, assistive technology improved the efficiency of learners as they engaged in writing and other academic activities[43] and enabled learners to "save time, reduce the physical writing load and to keep up with classroom demands"[4:444].

Limitations

The data collection procedure was influenced by a delayed response from the Department of Basic Education to provide permission that the research could be implemented. These logistic constraints led to a high absenteeism and a subsequent amendment to the study sample and inclusion criteria.

When conducting the study, the researchers did not observe the learners setting up their particular assistive technology, and whether they were able to do so therefore was not assessed. Another limitation of the study is that a non-standardised checklist was used to record the observations. Because the study was conducted on a small sample in the assistive technology programme at Tswellang Special School, the results cannot be generalised.

Recommendations

Research is needed to develop a comprehensive assessment instrument to evaluate all aspects related to assistive technology and its implementation, which requires application of the HAAT Model, which includes the learner, the activity, the assistive technology and the context and environment. Further instrument development procedures are recommended to improve the validity and reliability of the School Activity Participation Checklist.

Regarding clinical practice, occupational therapists should act upon their responsibility towards children's right to education by facilitating the use of assistive technology in all necessary clinical settings. Further formalised programme evaluation will provide context-based evidence regarding the effectiveness and suitability of this programme to ensure its sustainability. Additionally, we recommend that the programme be extended to other schools to meet the educational right of learners with motor impairments to inclusive education opportunities.

When addressing education and training, it is recommended that increased awareness, knowledge and clinical skills regarding assistive technology products and related services, be incorporated into occupational therapy undergraduate curricula. Occupational therapists need to be equipped to assess learners accurately, and stay updated regarding emerging technologies to ensure that learner-specific assistive technology is selected and implemented as a medium of service delivery.

CONCLUSION

The findings of this study yielded descriptive evidence that assistive technology could be a powerful enabler of participation in classroom activities for learners with severe motor impairments alongside their peers. It further reinforces the importance of the occupational therapist's role in the occupation of inclusive education.

The results provide preliminary context-based evidence for stakeholders to improve implementation, motivate for expansion and ensure sustainability of assistive technology programmes. Evidence of effective use of assistive devices for classroom activities, which can be adopted in similar settings is provided. Based on our findings, assistive learning programmes can also be proposed to government stakeholders as a preliminary plan to be rolled out on a national level. In alignment with international and national guiding initiatives, all health and educational professionals are called on to contribute to each learner's right to participate in the occupation of education, regardless of his or her disability.

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