6th International Conference on Research in EDUCATION, TEACHING and LEARNING
17-19 February 2023 Barcelona, Spain

Developing Low-Cost Resources for Teaching and Learning of Astronomy for Students with Visual Impairment at Primary and Lower Secondary Schools.

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Abstract

Astronomy is a highly visual subject, thus the teaching of a concept like the solar system is definitely a difficult task for teachers working with students having total visual impairment. In this study, some simple and low-cost teaching and learning resources are developed and presented, based on the request from teachers and representatives from the Special Needs Education Desk. One of the resources is a mnemonic and it can help to establish a relationship between concepts of the solar system and students' personal experiences. The other three resources developed in this study focus on tactile learning, and they can be used for teaching and learning in the classroom as well as a formative assessment tool. Some of the resources can be used during classroom teaching as they can help learners with total visual impairment to construct knowledge via two sensory channels (auditory and tactile). Furthermore, the technique used to develop some of these resources can further be extended to other science topics like electricity and other subject areas.

Keywords: tactile model, solar system, visual disability

1. Introduction

The Sustainable Development Goals, Target 4, stipulates that we must "ensure inclusive and equitable quality education and promote lifelong learning opportunities for all**".** Thus, we need to do our best to provide education to all types of learners, that are, children with learning difficulties, especially to students with disabilities and impairment. Moreover, Article 28 of the United Nations Convention on the Rights of the Child, highlights that primary education should be compulsory and available freely to all children. Mauritius is a Small Island Developing State in the Indian Ocean with around 1.3 million inhabitants and according to a survey carried out by the Statistics Mauritius in 2021, there are 2754 students enrolled in Special Education Needs (SEN) schools, with 85 students having visual

impairment (Statistics Mauritius, 2021). In 1983, the Loïs Lagesse Trust Fund (LLTF) was set up in the island by the government to cater for the needs of blind and visually impaired people by providing them with education, training and employment. The role of the Loïs Lagesse Trust Fund (LLTF) has been instrumental in enhancing the academic performance and holistic development of children with visual disabilities by providing them with quality education at pre-primary, primary and secondary levels (Mauritius Government Information Service, 2019). Other organisations which have contributed significantly to the welfare of people with visual disability are Lizié Dan La Main (LDLM) and Union des Aveugles de L'Ile Maurice. LDLM established a unit for students with visual impairment in a government primary school in 1995 **(**Lizié Dan La Main, 2006).

1.1 Adapted Textbook in Braille version.

In line with the work of Lois Lagesse Trust Fund and Lizié Dan La Main, the Mauritius Institute of Education (MIE) has started publishing manuals and textbooks used at primary level in the Braille version in 2020 to cater for the needs of learners with visual disabilities and to improve their academic achievement (Inside News, 2021; Mauritius Government Information Service, 2019; Bishop, 1996).

Table 1 shows 2 activities adapted from the Mauritius Institute of Education (MIE) Grade 6 Science Textbook, converted into Braille for students with total visual impairment. Science involves a lot of visual observations, and this requirement is very disadvantageous to visually impaired learners. However, educators do their best to convey the concepts in science through auditory, olfactory, taste and touch. As shown in Table 1, students with visual impairment can be provided with food items and fruits for the activity on '*Food Groups'*. Field trips/outdoor activities can also be used as a teaching strategy to enhance learning of such concepts.

However, if not carefully planned, science lessons may simply be reduced to teaching by telling. This seems to be the case for the second example given in Table 1, an activity on '*Threats to our lagoons'*. As educators, we should aim for understanding and application of concepts and not just having a mere awareness.

According to Fraser & Maguvhe (2008), learners with visual disabilities have difficulties in applying science process skills because they are seldom engaged in practical work and outdoor activities. The practical activities provided to these learners are often very simple and not intellectually challenging, thus impeding the development of advanced process skills like problem solving.

Learning resources can help to ensure the inclusion of students with visual disabilities (Temesgen, 2018; Webster & Roe, 1998). The latter pointed out teaching and learning resources, flexible teaching strategies together with special services from specialized teachers are fundamental requirements for quality learning of students with visual disabilities.

Temesgen (2018) pointed out that students with visual disabilities highly appreciate 'tactile teaching aids'. Similar ideas can be drawn from the work of Carney et *al.* (2003), who suggest the use of concrete, "hands-on" materials, and models to further support the understanding of abstract concepts by building on *tactile learning*. The latter can also be reinforced in the learning of science by providing students with equipment with tactile markings.

Table 1: Activities from the Mauritius Institute of Education (MIE) Grade 6 Science Textbook and their adapted version

Original activity from the book	Adapted version of the activity
Activity 5: Food Groups As all other living things, human beings too need food to live. Human beings eat different types of food; so they are **omnivorous**.  Figure 5: The market Observe Figure 5 carefully and after discussion with your friends, write the names of the food items you can identify.	*As other living things, human beings too need food to live. Human beings eat different types of food; so, they are omnivorous.* *Discuss with your friends and teacher and write the names of the food items that are normally sold in a market.* *Some food items that are normally sold in a market are banana, fish, meat, sweet potato, lettuce, bread, milk, yogurt, fruits, vegetables, chicken and fish.*
Activity 4: Threats to our lagoons **Group discussion** Observe Figure 5 carefully. It shows Samantha and her family at the seaside. Discuss about the threats to the lagoon and how they affect Samantha and her family.  Figure 5: Pollution in the lagoon	*Samantha and her family are at the seaside. Samantha and her brother are playing in the water, while her parents are sitting on the beach.* *There is a boat spilling oil in the sea water. There is a factory and some houses releasing their wastewater in a nearby river. We have some dead fish where the water of the river is getting into the lagoon. The factory is releasing smoke from its chimney. Smoke is also released by the burning of plants in a field.*

1.2 Adaptation of Astronomy for students with visual disabilities

'Earth, Moon and Sun in the Solar System' is a science topic in the school curriculum at both primary (Grade 6) and lower secondary (Grade 7) and is obviously a challenging one for both students with total visual disabilities and their teachers since this branch of science depends heavily on visual images.

Thus, the adaptation and teaching of this topic should be quite different from others since astronomy is usually known as a "highly visual science" (Noel-Storr & Willebrands, 2022), otherwise we run the risk of teaching by telling. Compared to other science concepts, field trip cannot be used as a strategy for this topic for blind students in our Special Need Education (SEN) schools.

During the recent validation exercises carried out by the Mauritius Institute of Education (MIE) on the adaptation of primary and secondary school textbooks, request has been made by both specialised educators and from representatives of Special Need Education (SEN) Desk to prepare teaching/learning materials for students with total visual impairment for the topic on Solar System. They requested the MIE Science/Physics teacher educators to provide them with resources or alternative ways of teaching the solar system than just translating the pictures given in the textbook into words. Three-dimensional (3D) printing seems to be a solution to this problem; however, SEN schools do not currently have 3D printers and some basic technical skills are required to design and print the 3D objects.

2. Method

Noel-Storr & Willebrands (2022) attempted to make astronomy more accessible to visually impaired people through the "multi-modal" method or by incorporating the maximum possible sensory perceptions in its teaching. Thus, drawing on the research of Noel-Storr & Willebrands (2022), we developed 4 innovative low-cost teaching and learning resources that can be used together with the adapted textbook, in the teaching of the Solar System at both primary and lower secondary levels.

Since this topic is a very visual one and we have to talk about the size, the distance of the planets from the Sun, the colour of the planets, the motion of the planets in circular paths, the resources that we proposed are also quite unique so that we can convey these messages, or at least part of them to our learners.

Low-cost materials such as carton, plastic pipe, bendable metal wire strips and small balls were used to develop the resources. Resources made from these materials have several advantages. They can easily be reproduced by educators and used in their classes and even stored safely for eventual classes. For example, carton is safe as a material. Its 4 to 6 mm thickness is an added advantage as it is very appropriate for producing an embossed artefact. Moreover, since the resources are being developed for visually impaired learners, the safety

aspect has to be looked meticulously when selecting the materials. Sharp and pointed materials cannot be used as we have to focus on the tactile learning skills of the students.

3. Results

3.1 Resource 1: The use of currency coins of various sizes and a watch cell

Figure 1 illustrates the first teaching and learning resource, made using currency coins of various diameters, a watch cell and a safety pin. The coins were arranged and glued on a cardboard sheet, in a straight line, with each coin representing a planet in the appropriate relative size.

Figure 1: Teaching and learning resource 1.

3.2 Resource 2: Mnemonic for representing planets in the correct order in the solar system.

In order to represent the planets in the correct order starting from the Sun, a mnemonic is used, or rather an English sentence as given below.

My Very Eager Mother Just Served Us Noodles.

However, it was found that the ability level of our learners in English language in general is not that proficient so that they can understand and use the given information in the sentence. Educators needed to come up with something similar but in the first language.

After some struggle, the following sentence in the language of the environment was developed:

Mo Voisin Envi Met Joseph So Uniform Nef.

Meaning: My neighbour wishes to wear Joseph's new uniform.

3.3 Resource 3: Carton cut-out shapes of the solar system

The amount of information given to learners through resource 1 & 2 relates to the primary curriculum. At the secondary level, learners are exposed to additional concepts such as dwarf planets/planetoids, orbits and asteroids.

We came up with a modified version of teaching and learning resource 1, where the feature of emboss was chosen as before, but the currency coins were replaced by carton cut-out shapes as shown in Figure 2.

Learners would thus be engaged through their tactile capabilities to explore the Sun, the 8 planets, the moon, a few dwarfs, as well as asteroids found between Mars and Jupiter, as well as those found beyond Pluto.

Carton sheet of 6 mm thickness was used to cut out all these celestial bodies so that when they are stuck on the base there would be a well-defined tactile experience by the visually impaired learners, similar to Braille characters.

The shapes of the Sun, the 8 planets, the asteroids, the moon and the dwarfs are cut out from the 6 mm carton and stuck on a rigid cardboard base. As far as possible the relative size and shapes of the celestial bodies are maintained. They may be slightly exaggerated only for making the learners understand the solar system.

These celestial bodies can be labelled in Braille characters so that it is easy for the learners to discover by themselves, the various features of the solar system.

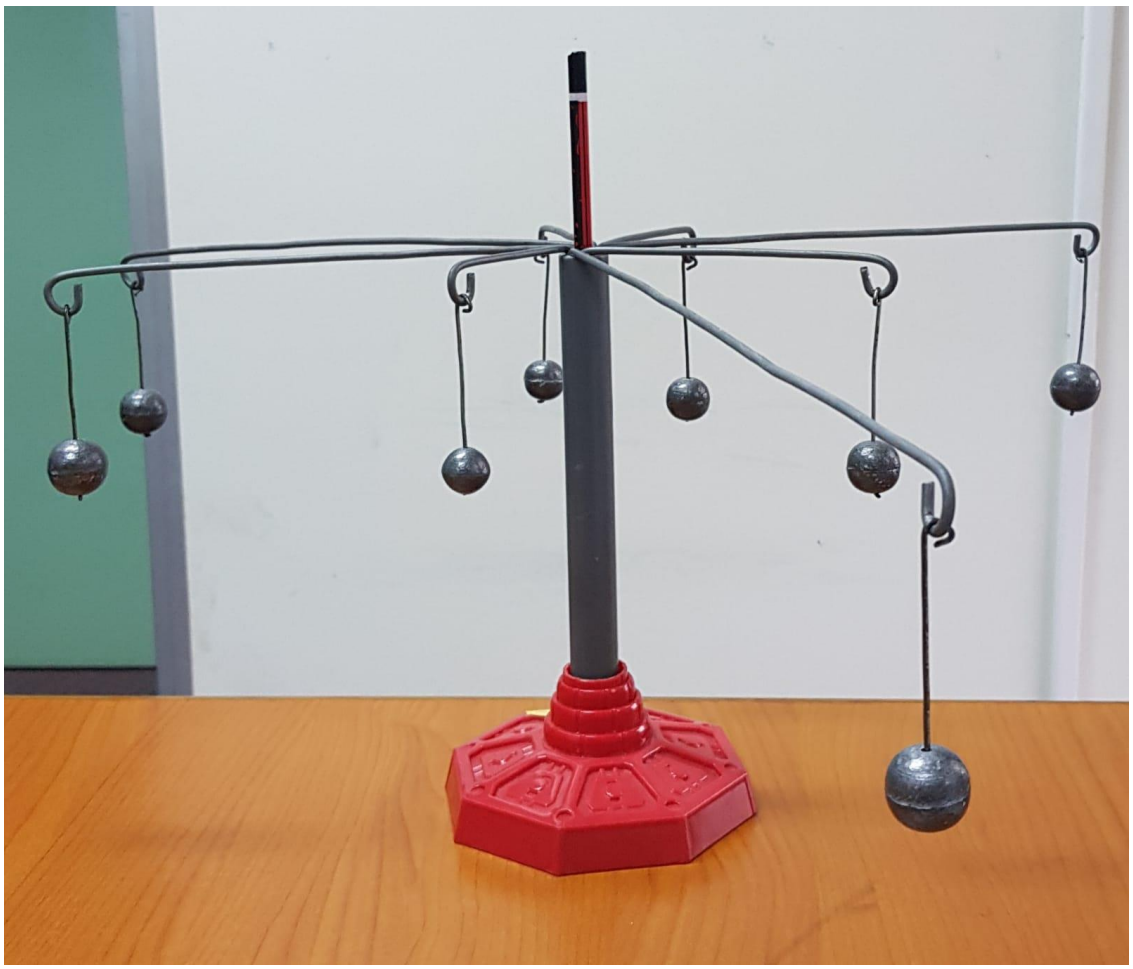
Figure 2: Teaching and learning resource 3.

3.4 Resource 4: Three dimensional rigid model of solar system

A rigid three dimensional model as shown in Figure 3 is used to consolidate the idea of the solar system.

Braille cards having information on each planet are included in this model. Learners explore each planet and read their respective cards for additional information.

Figure 3: Teaching and learning resource 4.



4. Discussion

There was a general appreciation of the development of these pedagogical tools by the panel members of the validation exercise.

Though resource 1 is a very simple representation of the solar system, it helps the learners to understand Saturn's rings. According to Carney et al. (2003), teaching and learning resources can help to establish link between the concept being taught and the student's experience. The sentence used as resource 2 relates very closely to the learners' environment. In a previous study conducted by Cyparsade & Adiapen (2012), it was seen that this resource has made immediate impacts on low ability learners in understanding and recalling the names of the 8 planets of our solar system. Thus, resource 2 would be of immense help to our learners with visual impairment.

Resource 3 greatly focuses on the tactile skills of our learners to decipher the shapes, relative sizes and approximate orientation of the celestial bodies, thereby reinforcing the

student's *tactile learning* skills (Carney et al., 2003). This resource has been developed due to the cardboard's ability to be cut easily into various shapes and sizes and being glued easily on a cardboard sheet. Three-dimensional printing may be explored eventually for doing the same.

Resource 4 seems to be a suitable intellectually challenging formative assessment tool as it can easily be linked to questions that are based on the size of planets, their relative positions with respect to the Sun, the size of dwarfs compared to planets, the size of dwarfs and planets as compared to the Sun and using the mnemonic to confirm the order in which the planets exist. Thus, this resource would surely meet the needs and enhance the development of advanced process skills among our learners (Fraser & Maguvhe, 2008).

Resources 1, 3 and 4 can also be used in conjunction with resource 2, and narration during teaching as they will help the learners to construct knowledge through 2 sensory modes (tactile and hearing) simultaneously. Thus, information is being conveyed to the brain through two channels (tactile and hearing) simultaneously, in the same way as a learner without visual impairment (sight and hearing) (Astronomy for Equity, 2022).

5. Conclusion

The aim of this study was to develop low-cost teaching and learning resources to help learners with visual impairment to have a better understanding of the solar system at the primary and lower secondary levels. Four such resources were developed and presented to pedagogical advisors and teachers working with students with total visual impairment. The resources were highly appreciated. Some of the resources are unique in the way they have been designed and they can also be used as formative assessment tools. Now, the next step is for educators to implement the teaching and learning of these concepts in their classroom, with or without the presence of the teacher educators or pedagogical advisors, and then share their feedback and experience with the curriculum developers for further improvement. This feedback can also be used while developing materials for other topics such as electricity where lots of circuit components, and circuitry are desirable.

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