Exploring the Barriers and enablers in Learning of Astronomy for Vision Impaired Learners

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Abstract

Astronomy being a Science associated with visual representation is considered to be difficult to learn for the vision impaired (VI) learners. The authors of this paper had used a Technology Based Inquiry Learning Approach for creating equitable learning opportunity that aimed to provide conditions to learn Astronomy concepts for all students. The present article explores the factors which represent barriers and enablers to participation in Astronomy classes for VI students. Semi-structured interviews were conducted with eleven VI students who were studying in Standard 6th in a special Education Institution in Mumbai. The daily reflections of the authors and the observations of the facilitators were also collected for the study purpose. Interpretative Phenomenological Analysis revealed six higher-order themes: the academic constraints, curricular adaptations, pedagogical intervention, optimum use of assistive technology, unquestioned trust in the learners and partnering with the stakeholders. The first theme being a barrier whiles the remaining being the enablers. The paper presents the concluding remarks with reference to the equity in Education for all disabled learners.

Keywords: Vision Impairment, Technology Based Inquiry Learning, Assistive Technology

1. Introduction

”Education for All” has become a common concern with a focus on positive attempts to achieve equity in different educational systems. Equity in education can be achieved by teaching students corresponding to their level of readiness, their interests and their learning style, maximizing their opportunities for personal learning and growth (McLaughlin & Talbert, 1993). In this framework, equity in education and social justice can only be met if teachers find the strategy to correspond to the diversity of their students (Gamoran & Weinstein, 1995) through differentiated instruction.

One of these groups of learners whose access to knowledge and critical learning experiences is marginalized due to lack of research based instructional practices and societal misconceptions about their abilities is the students with vision impairment (VI). In spite of several educational policy reforms and progressive movements the doors of certain fields of knowledge have not yet wide opened for these learners. Astronomy is one of such fields which have remained inaccessible for these learners due to its abstract nature and focus on visual representations.

We (the authors of this paper) have made a humble attempt to implement instructional differentiation for developing conceptual understanding about certain Astronomical concepts among VI learners from standard six studying in a special educational institution at Mumbai. For this a constructivist learning path namely "Technology Based Inquiry Learning Approach (TBIA)" was chosen.

The following section presents brief theoretical framework followed by the description of the intervention. The subsequent two sections present the methodology of the present part of the study and the results revealing the barriers and enablers of making Astronomy content accessible to the VI learners. The last section presents the key learning of this study.

2. Theoretical Framework

Carol Ann Tomlinson (2001) defines: Differentiation as tailoring instruction to meet individual needs. Differentiated instruction is a process to teaching and learning for students of differing abilities in the same class in which the Teacher differentiates content, process, products, or the learning environment for meeting the learners' individual needs.

Supporters of differentiation and its effectiveness state that differentiated instruction is the only way for effective teaching for all students in mixed ability classrooms (Tomlinson, 1999, 2001; Koutselini, 2006). Differentiation guides the planning and instruction in mixed ability classrooms based on students and their needs, facilitating the construction of knowledge for each and every student based on its prior knowledge.

Differentiated teaching is the learning process in which students are facilitated to construct their knowledge by maximizing motivation for cognitive and metacognitive growth that will eventually improve academic outcomes for all students (Koutselini & Gagatsis, 2003) and strengthen their explanatory faculty. Construction of knowledge is a learning process, where each and every person understands and gains meaning of new knowledge based upon their prior knowledge and their personal beliefs and needs. In a constructivist learning process where differentiation is applied, a child-centered teaching approach sees every student as a unique creation. Consequently, differentiation is the answer to the needs of each student and the facilitation of construction of knowledge for each student (Koutselini, 2006).

Providing opportunities for each child to construct knowledge through equal access to learning will help to create equitable learning environment and this will be possible only through differentiation of instructional practices combined with constructivist path.

Hence we have chosen the differentiated instructional approach for facilitating the learning of Astronomy concepts for the VI learners. We adopted the constructivist paradigm while organizing the critical learning experiences. For this we implemented the instructional design based on technology based inquiry learning approach (TBIA). The next section presents the brief overview of the intervention program.

3. The Intervention

This intervention program was based on quasi experimental research design and took a mixed method research paradigm. 22 VI students of Standard sixth from two special schools for the students with vision impairment in Mumbai (Kamala Mehta School for the Blind girls and Victoria Memorial School for the Blind) were the participants of the study. The students from Victoria Memorial were in experimental group while the students from Kamala Mehata were in control group. Two instructional designs based on four major themes namely: Solar system and the Galaxy, motion of Earth and its types, occurrence of day and night and reasons for the seasons were developed. The experimental group was chosen for the instructional design based on TBIA while the content for the control group was transacted by the traditional method. We chose 5 E learning cycle for the TBIA. The duration of each design was 6 sessions of 2 hours each.

The pre and post test for conceptual understanding and pre and post surveys for the attitude toward Astronomy and science curiosity were administered to find out the effect of the treatment. Pre and post oral test was administered to examine the emergence of conceptual change in Astronomy concepts.

As a result of the analysis of data, there were statistically significant differences between experimental and control groups. According to results, the achievement level of the experimental group with TBIA was significantly higher than the control group with a traditional teaching method. The similar results were found for the attitude towards Astronomy and Science curiosity. The qualitative analysis of the data also supports the finding that TBIA is more effective and successful than traditional teaching methods in developing conceptual understanding about the Astronomy concepts among the VI learners.

In this journey we met with several enablers while we also had to cross some barriers in promoting learning of Astronomy concepts among the VI learners. The purpose of this paper is to study the barriers and the enablers in VI students' participation in TBIA based Astronomy learning experiences.

We specifically sought to answer the following research question:

RQ. What are some of the factors which represent barriers and enablers to participation in TBIA based Astronomy learning for VI students?

4. Methodology

As teacher educators of secondary level of schooling we have undertaken and guided several research projects in the area of inclusive education and constructivist learning pedagogy. Hence our current area of interest is technology based inquiry learning for the VI learners in Science Education. We have spent many hours reviewing existing researches, discussing with the experts in the field of Special Education, visiting special education classrooms, and making presentations on an inquiry approach which is what sparked our initial interest in this project. We were very much eager to hear the voices of the participants and their perspectives about the use of TBIA in facilitating the learning of Astronomy for the VI learners.

Keeping in mind the purpose of the project a multi-site phenomenological methodology was utilized. According to McMillan (2008) a phenomenological methodology is used in order to gather and interpret lived experiences of various participants within the same phenomenon. Each participant may have a different experience but each is within the realm of reality for that participant. A phenomenological study fits within the qualitative research paradigm. McMillan (2008) indicated that participants in a phenomenological study are chosen because of their experience with the particular phenomenon being researched. Since the phenomenon in this part of the study was technology based inquiry learning of Astronomy concepts, we chose 11 VI learners from the experimental group. We also decided to hear the voices of 10 field workers who assisted us in our project. But they were not directly involved in this part of the study. Their observations were used for corroboration purpose.

- **Participants**

The participants of this part of the study were 11 VI students from Victoria Memorial School studying in Std 6. All the students were males. Out of 11 students 3 were totally blind, 3 had only light perception and 5 were partially sighted. There age ranged between11 to 16. Of all the students only 2 knew Braille fluently, 3 could not read and write it fluently and 6 did not know Braille at all. Thus 9 students could not use Braille for their study purposes. They depended on sighted readers or audio materials for their studies. Out of 11 students 6 could use screen reading software JAWS. The performance of all the students in pre-test was very poor as none of the students could pass the test successfully.

- **Data Collection**

In this study as already indicated above, we wished to analyse in detail the experiences of the researchers and the field workers about using TBIA for teaching Astronomy to the VI learners and the perceptions of the VI learners regarding learning Astronomy through inquiry process , we gathered data through the Focus group interviews of the VI learners to engage in a flexible dialogue with the participants in the study. Interviews were audio-recorded with the consent from the participants. The interviews were then transcribed verbatim. To establish trustworthiness of the findings, the interviews were conducted by two different researchers. We also collected the researchers daily reflections and field notes of daily observations of the field workers .

- **Data Analysis and Standards of Validity**

Our goal was to "understand participants from their point of view" which could result in multiple 'realities' as each participant expresses his or her own experience. This is why it was important for us to use a phenomenological methodology to bracket our own perceptions of reality regarding the phenomenon being researched. This was important so that as the data is being collected and subsequently analyzed so that the true voices of the participants are heard. Bracketing or setting aside of personal bias and prejudice from the onset is one of the validation strategies outlined by Creswell (2007).

We also incorporated other validation strategies in this project outlined by Eisenhart & Borko(1993) They were as follows:

1) The project is built on existing educational theory,

2) the research question drove the data gathering and analysis,

3) criteria were established for involving the specific participants,

4) a competent data collection technique was applied, the use of interviews which provided rich descriptions for analysis.

In order to increase the degree of reliability all interviews were audio-recorded then transcribed. All the text of researchers' reflections and field workers' observations were also transcribed. All of these copies were read over many times in order to identify themes. Blind coding was used for this purpose. A constant comparison method was utilized to further break down the themes. As a final method of linking the data findings together a graphic map was created from the second matrices which then outlined the data into six major themes.

5. Results

Six major themes emerged from the data the

1) Academic constraints,

2) Curricular adaptations,

3) Pedagogical intervention,

4) Optimum use of assistive technology,

5) Unquestioned trust in the learners and

6) Partnering with the stakeholders.

The first theme represents the barriers to the participation of VI learners in Astronomy learning experiences based on TBIA while the remaining five themes represent the enablers in this process.

Following is the discussion of the major theme:

1. Academic Constrains

- Challenges in connecting to course content-It was noticed that the special schools for the VI students are using the same textbooks only they are made available in Braille print. As a result these books not only lack in appropriate graphical presentations but even the content as well as the vocabulary used in the content is not at all accommodative. Hence, the content largely remains out of reach for the VI learners.

- Lack of resources-The school chosen for the experimental group did not have sufficient learning resources like models, charts etc. Whatever they had also was not in a good shape.

- Non conducive class management-Inquiry required the self exploration of the materials in Braille or in digital form, models or audio form. Which was many a times difficult for 5/6 students. It was risky to make them touch the electric bulbs in the models as well.

- Classroom navigability- The regular classroom seating arrangement with desks and benches in the school also made the initial process of learning difficult as there was no scope for group work on the work stations. The students used to stumble and fall on each others.

- Lack of inquiry and collaborative learning skills-According to research findings, students learn content best when: they are involved in firsthand exploration and investigation and inquiry/process skills are nurtured; instruction builds directly on the student's conceptual framework. When engaging in inquiry, students are expected to describe objects and events, ask questions, construct explanations, test those explanations against current scientific knowledge, and communicate their ideas to others. They identify their assumptions, use critical and logical thinking, and consider alternative explanations. For this it was required that the learning materials are in accessible form for the learners. But as mentioned earlier 9 students could not use reading material in Braille form out of 11 only 6 could access reading material with the help of screen reading software. School did not have any models accept a globe.

Besides, despite widespread agreement on the importance of inquiry-based learning, it was difficult to adopt this pedagogical approach in classrooms. Initially we found that students were getting disruptive, paying less or no attention, or simply not participating. It was because the students were used just to get oral information from the teacher's mouth and memorise it.

Inquiry learning needs the self exploration of material, observation and conclusion which required sufficient time, suitable classroom setting and wherever required a readily available sighted assistance for totally blind learners to perform certain activities.

Along with the inquiry skills the students also lacked in collaborative learning skills which initially hindered the process of group work. All this made initially the process of technology based inquiry learning complicated for the learners as well as for the facilitators.

2. Curricular adaptations

- Content accommodation- As mentioned earlier the astronomy course content was largely inaccessible for the VI learners due to the lack of graphics and conceptual complexities of the themes. To solve this issue we did a thorough content analysis of the Astronomy content; identified the complex areas and provided textual scaffolds by creating new learning material. We used the latest technology to introduce the graphics in tactile form.

- Linguistic scaffold- The Astronomy content had lot of visual elements which were presented with the language meant for the sighted persons: like- when we look in the sky…, look at the twinkling stars … , we see the milky way …, etc . Similarly the description of many phenomena like equinox positions and solstice positions etc was also difficult to understand for the VI learners. This required not only the tactile diagrams but even the detail description of these diagrams by guiding the learners for exploring these phenomena. We did provide this textual description for these learners.

- Assessment accommodation- The challenge here was how to assess the inquiry learning among VI learners, how would the marking criteria be applied in the same way as for other students when some of the student had a sighted assistant, how strictly to follow the marking criteria .

We found the following solution for this issue.

We decided to mark the students based on the three criteria:

1. Inquiry skills,
2. Conceptual understanding
3. Group presentations

Inquiry skills are marked on whether the student has participated in the following activities:

- Asking questions
- Accessing information
- Sorting information
- Reporting finding

The totally as well as partially sighted students tended to score well on this.

- Conceptual understanding was to assessed by marking them on understanding of the Astronomy content and performing certain practical activities. Initially the students were presenting a very sketchy notes on the assigned tasks.Some leeway was given here as it was felt to be unreasonable to expect such a comprehensive written account. However, when it came to writing up test paper no such leeway was given.
- Group Presentation skills were also straightforward to mark. We marked the students against certain dimensions like content clarity, logical organization of the content and group coordination.

3. Pedagogical intervention

- Adopting guided inquiry learning steps- As mentioned earlier the VI learners initially lacked in the inquiry learning skills. To overcome this problem,we adopted easy step by step guided inquiry strategy in which students were guided from one stage to another with the help of structured observations, interpretations and conclusions.

- Collaborative grouping – The participants were a very heterogeneous group with varying degree of sight, Braille competence and technological skills. It is therefore adopted a collaborative learning approach and made the groups of totally blind and partially sighted students and gave each group one field worker as a sighted assistant . We also saw to it each group at least one person could read Braille or could access digital material effectively.

- Role of students in TBIA environment- This sub-theme emerged from the field workers' reflections and observations. This theme was similar to ones found in the literature. All ten field workers defined TBIA differently which was consistent with the varied definitions found in the literature reviewed. Some of the key phrases used in defining TBIA were: student led, based on student interest and questions, an opportunity to explore, structured, not so structured, not driven by curricular outcomes, a way for students to come to their own understanding and take ownership of their learning. One idea that was expressed numerous times in the data collected was the idea of TBIA being based on the "interests of the students. The idea of TBIA being a process of collaboration and investigation was expressed by eight field workers. Collaboration or working with others is a key tenet of the social constructivist theory and a vital part of the learning that occurs. Three field workers felt TBIA as an "enrichment activity for an advanced student." Here is an excerpt from one of them: Sandesh's(Pseudonym used) knowledge base in area of Astronomy was far greater than others. He approached to me with a topic of" location of the places and local timings) for his query. He came up with the idea of finding the major cities of the world and local timings there. I got him working on the talking mobile and we generated some questions he wanted to know more about and he came up with ways to find the answers. He got all the other students excited about the topic. He was able to take it to his own level and really took off with the inquiry question."

This shows that the TBIA enabled the VI learners to be the active generators of knowledge.

- Learner specific focused experiences -Because each of the students was at a different age, degree of vision impairment, and knowledge level in Astronomy, the project could have easily fallen into the trap of teaching to the so-called lowest common denominator. This would have had the advantage that no student gets left behind or confused by any of the activities, but it certainly would have also limited or constrained the learning experience of those students who had a stronger base in Astronomy prior to the project . One student talked about how well the project team dealt with this issue of students' learning process. He said " I was pretty familiar with astronomical topics, But I wanted to know more and more interesting things about the motion of the Earth, different planets which is not there in the textbook. But the team members gave me all the information what I asked for"

4. Optimum use of assistive technology

- Need-based approach to the selection of technology- As mentioned earlier the VI learners differed from each others with respect to their functional sight, Braille competence and skills in using assistive technology. Since TBIA required the self exploration of learning resources and there after observation and generalisation, it was essential to make these learning resources accessible to each learner. It is therefore we made these resources available in Braille with tactile diagrams, audio form and even in DAISY (Digitally Accessible Information System). We developed a short movie on solar system with audio description and a talking model of the same with touch start technology.

- Enriching experiences- The VI learners were happy and very much appreciative of certain learning experiences provided to them. They found the movie on solar system very exciting. They liked to work with the talking model of the solar system and on the top of it they enjoyed the touching the dome which gave them a feel of a sky. Rohit said" Wow! Great to touch the sky!" Ashwin said" So interesting to know about the planets from the talking model."

- Engagement with learning support- The VI learners felt grateful about the learning support provided to them in the process of Astronomy learning. Soham said very emotionally" Thank you teachers! Who will do so much for us" Kartik said" I never thought that even a blind boy like me can know even a little, on my own , about this universe". These were their feelings after accessing the resources in audio and DAISY format as well as experiencing with talking model.

5. Unquestioned trust in the learners

- Unrestrictive access to learning experiences- This was a very prominent theme which immerged from the focus group interview of the VI learners. All the participants unanimously felt that the research team showed lot of trust in them. Shubham said "For the first time someone has allowed us to touch the models, apparatus independently. Earlier we were never allowed to touch the things on our own. Sidharth said" We were not scared to touch things as we knew all the team members are supportive and if anything would go wrong no one would scold us". Several of the students mentioned how surprised they were that the research team allowed them to actually work, hands-on, with the models, graphics etc. As with all young people, there exists a strong desire among these students to try things on their own without someone stepping in and doing things for them. Ankit said" People do not let me do things myself. They would either put their hands over mine and show me, or they would just do it themselves or not let me do it at all. So, I think this was great". By allowing the students to work on their own and develop confidence with some expensive and delicate equipment, the research team showed the group that they were genuinely interested in their learning experience and had trust in them as a learner. This fostered an atmosphere in which the students felt comfortable to show even what they didn't know by asking questions to the research team.

- Content differentiation as per the learner ability –The research team saw to it that each child's identity is respected. We did not only cater to the interest of the advanced learners but also slow learners find their place in the TBIA process. We raised inquiry questions of varying difficulty levels. We also tried to accommodate the totally vision impaired learners in self exploration of the learning resources by adapting them technically.

6. Partnering with the stakeholders

- Facilitators' willingness to adapt- The participants appreciated that the research team members were very willing to know the problems faced by the students and very prompt to bring changes in the activities. Mohit said "The team members asked me whether I could understand the concepts, what changes I need in the diagrams or models. Nobody has asked me like this before" Niruj also felt the same and said" The project teachers were always ready to know about my problems and they always asked me how I would have liked to be taught. Who does so much for us?"

- Respecting learners' desires- During the process of exploration of solar system the learners also wanted to know in detail about the space craft , the day of a cosmonaut , biographies of Indian cosmonauts etc. Looking at their curiosity we even fulfilled their wish after the project program was over.

To conclude, we can create equitable learning environment for the marginalised sections of the society including the VI learners by:

- offering the opportunities and choices of the modes of learning to the learners,
- providing equitable access to all,
- building curriculum supporting and reflecting the priorities of the learners,
- celebrating diversity among the learners,
- meeting the aspirations of each learner, and
- developing innovative approaches to reaching out the learners.

6. Key Learning

This study illustrates the following:

a) Teachers need to be aware of situations in which they may be although unintentionally reducing the academic requirements for students with disabilities.

b) The best accommodations are developed when the student and teacher communicate clearly and work together.

c) Accommodations do not need to be costly. Often, low-tech adaptations can be made with materials and equipment that are readily available in the surrounding.

d) The presence of a student who has a disability can raise the awareness of access issues for those with whom they regularly interact.

In this case, simply by interacting regularly with the students who were visually impaired, we became aware of the access challenges they might be facing.

e) Access barriers for a specific student with a disability can be best resolved when the resource developer works in collaboration with the student.
f) The need for making accommodations for a specific student can be minimized if universal design principles are employed at the time that resources are being developed.

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