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Teacher Mediation in an ESL Science Education Context

Abstract

The widespread increase in English-medium schools across India including the emergence of the low fee paying/budget school sector places many students and teachers in a situation of subject teaching in what are effectively English as Second Language (ESL) contexts. Given the absence of language across the curriculum and ESL related preparation in preservice teacher education, interested teachers devise their own strategies to enable students to negotiate the dual requirements of language and subject learning. The present article is based on a case study that explores the practices a science teacher working in a charitable school in Hyderabad. The mediational practices are documented and explored in relation to the literature. Her dominant technique is found to involve bilingual meaning-making of concepts drawing on everyday contexts of students and developing their observation and reasoning. Her language focus emerges as the learning of the language of science rather than English per se. These practices compare well with the literature. The article concludes with reflections on the sources of this teacher's practices, and proposes that her autobiographical experiences, her interest in science and understanding of the nature of science and finally her reflective practice account for these practices.

Introduction

India has seen a mushrooming of low fee paying English medium private schools catering to a working class and lower middle class population that is aspiring for English and for whom 'English medium' has come to be identified with 'quality' (Jain et. al 2018). Thus there is a growing population of school goers who are in English medium schools for whom English is effectively a Second Language (ESL), and for whom the only access to the language is at school. Teacher professional development in India does not prepare science teachers to address such contexts. Teachers either fall back on traditional rote learning and memorisation to enable students to pass tests and examinations (Sarangapani 2018), or else invent their own methods and strategies to teach for meaning making and understanding, drawing on their folk pedagogical theories (Bruner 1996) and their aims of education. This paper is based on a study that looks at the efforts of a science teacher teaching science to middle school students in an ESL context.

[1]This paper is based on the doctoral research of the first author carried out under the supervision of the second author.

The research was designed as a case study of one middle school science teacher, selected for her reputation as a 'good' teacher, engaged with science teaching in an English medium charitable school for students from Telugu speaking working class in the city of Hyderabad. Students accessed English predominantly only at school. The study was designed to document and understand the practice that the teacher had developed through her own reflection, experience, knowledge and understanding of the linguistic and social context of the children.

The literature on science teaching to underprivileged students involving bilingual contexts notes the importance of pedagogies that contextualise learning and focus on meaning making (Tolbert and Knox 2016) or drawing on funds of knowledge (Moll et al, 1992) and supporting students' identities as learners (Gee 1997). Yerra (2010) has noted the complexity of science textbook language observing that there is a preponderance of usage of present and present perfect tense and participial use of verbs. The comparative study of verbs across subjects reveals that polysyllabic verbs were more in number in Science and Social Science textbooks while the English texts had the highest number of monosyllabic and disyllabic verbs. When the readability grade VII English, Science and Social Science textbooks of five pubications were compared, it was found that the readablility of the English textbooks is at the level appropriate for the grade chosen (Class VII), that of the Science textbooks matches a higher grade level (IX,X) and that of Social Science textbooks is at a still higher grade level (XI,XII). Given the language demands made by science textbooks which were found by the first author as a part of her MPhil work (Yerra, 2010), this study explored how a teacher would negotiate the language demands of teaching science to students who have Limited English proficiency (LEP). The main part of the Data analysis involved analysing 40 observed and audio-recorded sessions of the classroom and initially a total of nine themes were generated from the data in accordance with the research questions and the transcripts/ audio records were coded using the qualitative analysis software, MAXQDA (*version 12.1.2*). Eventually many more themes emerged and while organizing for analytical insights it became evident that these themes could be categorized into the four pedagogic phases (three of which are discussed in this paper) that the teacher was following. Survey questionnaires and artifacts/ documents served to explore teacher beliefs and to gain an understanding of the contexts of the teaching-learning situation.

The dominant tendency of Indian education system is one of rote learning with an examination focus (Kumar 2004), and such a textbook based pedagogy directed at memorisation has been noted to dominate private English medium schools catering to LEP students from working class sections of society in the city of Hyderabad (Sarangapani, 2018). However, in contrast, this teacher was observed to be teaching for meaningful science learning in English. She was found to have evolved strategies in which she drew upon bilingual code switching (between Telugu and English) and also on her understanding of the nature of science as an empirical body of knowledge developed from and relevant to observation and reasoning about everyday phenomena. This paper presents her key strategies which included: (i) ensuring that students understood the scientific concepts and could reason about them independently, for which she freely used Telugu and

drew on everyday experiences of the students (ii) supporting students to transition into scientific language/ terminology in English, with scaffolded code switching (Gonzales et al, 1993) including by peers.

Findings

The teacher's lessons generally followed three phases of distinctive work. An initial phase conducted mainly in Telugu, was devoted primarily to meaningfully understanding the concepts and phenomena of the lesson, where she drew on everyday experiences and context, and the observation and reasoning aspects of the nature of science. A second phase focussed on transitioning to English, involving learning of scientific terms and expressions. The third phase focussed on ensuring that students learnt to recall and give answers in English for the purpose of examinations. This pattern was generally consistent with what has been noted of Indian teachers as focussing on a phase of teaching followed by a phase of learning (ensuring students remember and can answer exam and test questions). The strategies that the teacher adopted seemed to be aimed at ensuring that even as students learnt to give answers in English, it was linked to meaning and understanding that had been constructed in Telugu, and students were confident in their understanding.

Developing Meaning and relating to Context: The teacher mostly began every new topic with an introductory phase with practices that facilitated an understanding of the science content, with extensive use of mother tongue, general descriptions relating to context in non-technical language. Telugu was used not only to translate at word, phrase or sentence levels, but more generally to develop comprehension through narration of real-life examples and anecdotes drawing analogies, while making demonstrations, or doing activities. She also encouraged students to reason and make inferences. Generally, after students read out portions of the textbook, she elaborated using Telugu liberally and frequently.

Episode 1: Topic- Changes Around Us.(Translated from Telugu. Words/ phrases which are spoken in English are underlined.)

Teacher asks for examples of those things that rust.

A few students shout out: Near the cycle wheel Teacher.

Teacher: Aah! Very good! Near the cycle wheel, it forms like rust (*thuppu).* Does it not?

Students: Yes Teacher! Yes Teacher!

Teacher: Then why does it not form at the handles and the cycle seat?

Students: There are plastic handles there. Isn't it?

Teacher: And if I remove all the plastic and put it aside?

Students: We can clean without allowing water to fall on those places.

Teacher: And if I keep pouring water. And I keep pouring till it drips down.

Students: On that steel part, they put polish-like paint, and that keeps it from rusting.

Teacher: Very good! Excellent! That is called galvanization. What did I say?

Students (chorus): Galvanization!

Teacher: Polishing or Painting any metal things is called galvanization.

(Teacher continues to explain the process of galvanization in Telugu.)

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As we see in episode 1, The content was elaborately discussed in Telugu drawing on everyday experience of rusting, with the final core idea being formulated in English, after which she went back to discussing processes in Telugu. In episode 2, she invited them to reason about the process under discussion, using familiar analogies, and engaging with 'talking science as a way of doing science' (Lemke 1990). We notice her use of English for critical terms/ important vocabulary.

Episode 2:Topic- Seed Dispersal. (Translated from Telugu. Words/ phrases which are spoken in English are underlined.)

Student reads a question which is part of the text (not question at the back of the book) "<u>What will happen if all the seeds fall in the same place and germinate producing plants?</u>"and looks up at the teacher

Teacher: Tell what you understand?

Student: If all the seeds fall in the same place what will happen?

Teacher: If all the seeds fall in the same place and <u>germinate</u> producing plants? I took many tomato <u>seeds</u> and put them in one <u>place</u>.

Teacher: What will happen? Will they grow happily?

Student: Yes teacher.

Teacher: (expecting that they should have disagreed with her cues them saying) aaa?
There is a confusion of voices, some Students saying' they will grow', others saying 'they will get mixed up. She then continues: If two more students come and sit on a bench on which there are already three students sitting. If I make you all sit in one place, how will it be?

Students: Not possible (*kudharadhu);* uncomfortable.

Teacher: will it be comfortable? Can you listen? <u>Can you write</u>? <u>Can you draw</u>? Aaa?

Students (chorus): No teacher!

Teacher: Just like there is no space to even sit properly, if I put all the seeds in the same place, they will germinate and sprouts will grow, then what will happen? Space will not be there. Now there is a <u>competition for Air, for space, for sunlight.</u> (She continues gesturing to the bench example, that the one sitting in the centre, if she gives one push all the others will fall down.)
Students laugh.

Teacher: We call this <u>Survival for the Fittest.</u> The plants that are <u>strong</u> will live and the other weak ones will die. When you go home today, sow a handful of mustard seeds. First many will grow, then slowly they will reduce in number, the <u>strong ones</u> will <u>survive</u> the <u>weak ones</u> will die. It will not get enough <u>air, water</u>, in that manner <u>finally only</u> a few plants will remain. Did you hear? There will be <u>competition</u> with the <u>mother plant</u>. Their mother also will be there only no? There will be problem of space, water, sunlight, everything no? So in order to prevent that <u>competition, dispersal</u> is <u>main</u>.

(Session: 15)

She frequently used 'why' questions. These questions were directed at everyday phenomena: why do taps get rusted and not bicycles?; to superstitions: why should one not sleep under tree sat night?; to demonstrations: why do certain fruits

and vegetables when cut become brown after some time; to general issues: Why the Taj Mahal was not actually white?; and was even used as a way to manage the classroom: Why time was very crucial and they cannot afford to waste it? / Why the students could not be taken to the Laboratory?

Translation seemed to be used to re-express everyday English expression into scientific expression that was expected in textbook learning and for the purpose of examinations. This is discussed in more detail below.

Transitioning to English: The school was English medium, and students were expected to ultimately take examinations and tests in English, as well as the board examination in English medium in grade X. It was notable that the teacher focussed on meaning making in the first phase of each new lesson, and chose to interact with children mainly in Telugu, using English terms and phrases occasionally. The second phase of teaching each new topic involved a greater focus on enabling students to grasp the language of science in English, but without shifting away from meaning-making, switching code between Telugu and English, in what seemed to be an effort to enable students to 'latch on' to the language of science. For example after first explaining an experiment in Telugu line by line, the teacher switched code, repeated and use cued questioning to scaffold students to recall and use specific vocabulary. Code switching was not only between Telugu and English, but also between everyday English and the language of science. She simplified complex sentences. This teacher often broke sentences down point wise, and used simple everyday words in place of more technical ones: e.g. 'moisture' in place of 'humid', 'watering of plants' instead of irrigation 'giving' in place of 'sprinkling',

'leaving' in place of 'releasing'. She also connected new terms to ideas they had already encountered: e.g. in a lesson which had the concept of 'corrosion' she recalled a phrase from previous lesson where a reagent had "corroded the metal containers".

English was used for transactional purposes in classroom management, involving standardised instructions and routines: 'stop talking', 'sit down', 'now copy down the 4th question', 'listen carefully everyone'. However, while correcting notebooks she used Telugu while pointing out mistakes that the students had made or drawing their attention to what was important.

In general the pattern followed was that after spending initial time in developing meaningful contextual understanding in Telugu, she encouraged them to think of the phenomena and convey their understanding initially in everyday English. Following this, she scaffolded them to translate their everyday English explanations into scientific English. This was a phase of repetition and rehearsal, with the focus on answers to questions. Students often prompted each other, usually supplying the correct English term. She freely allowed such horizontal interactions during in the course of teaching. We see in episode 3 how S1 was prompted by another student S2 as well as several students, several times, to complete answers to questions asked by the teacher. She did not prevent this, but allowed him freely to be prompted and assisted by them. This was observed on several occasions. However, when the focus of her teaching shifted to ensuring that each student 'learnt' (see next section), she was 'conventional' and disallowed such prompting by others.

Episode 3: Topic- Soil Our Life. (Translated from Telugu. Words/ phrases which are spoken in English

are underlined.)

Teacher: What do you understand? S1 will tell.

Student1: They both are making some ..some different.. models of vegetables

Teacher: Vegetables. Very good. With?

Student1: With ..

Student2: with soil and water.

Student1: with soil and water.

Teacher: with soil and water okay.....

Student1: then ... then they both are ...

Teacher: hmm? Aa?

Student1: then they both are not satisfied.

Teacher: hmm..

Student1: their models are ..

Student2: models will break.

Student1: their models will break.

Teacher: hmm... so ?... what happened?

Student1: They went to ..they went to grandma and asked to them.

Student2: The grandma said to make models.

Teacher: What she told ? What grandmother told ?

Student1: To make models...

Teacher: Where we have to collect the soil?

Several students: From bank of village pond.

Student1: From bank of village pond.

Teacher: From the bank of the ?

Several students: River.

Student1: River.

(Session: 24)

Ensuring learning/remembering: It has been noted that teachers in mainstream Indian schools spend time in ensuring that students have 'learnt' what has been taught. In other words, time is spent in revision, rehearsal, and quizzing, to make sure that they can recall write answers, enabling them to perform as is expected of them, in examinations (Sarangapani, 2018). This phase included those teacher practices that were directed towards enabling the students to learn the language of science along with its content and enabling them to prepare for performance in examinations. After the teacher emphasized on meaning and then shifted to focus on the English language in the science content, her next logical step was to enable the students in learning of science and she used several practices for this: notes writing, cued questioning and repetition, correcting notes, and providing study and revision plans. This teacher wrote out some of the answers to questions, and guided the students to write some answers in their own words. She regularly assigned revision of question-answers of a chapter as homework which was followed in the subsequent class with oral question-answer session, sometimes also led by a student monitor. Sometimes this revision was also undertaken in pairs in the class, with one student asking the question and the other repeating the answer. This final phase of work in each lesson was conducted in English and with a focus on English.

Discussion and conclusion

This teacher had developed various strategies and techniques to teach science meaningfully to this group of students who had limited English proficiency. The techniques she employed described above are consistent with observations in the literature on effective science instruction in bilingual contexts. Her strategies compare well with what Tolbert and Knox (2016) and Moll et al. (1992) have noted about the importance of developing meaningful context to support the student's learning. In her use of the nature of science and the method of science as empirical, based on observation and inference we also find her supporting students' epistemic identities as confident, autonomous learners, who

must learn to trust their own reasoning ability, and develop their own thinking and reasoning (Gee,1997). Language used is the language needed to support this thinking and reasoning. In this we find her strategically switching between Telugu and English and the learning of scientific terminology becoming the key language challenge to be tackled.

Pre- and in-service professional development in India does not prepare teachers to address the diverse linguistic requirements of their classrooms. Considering that there was no professional development input that supported this teacher to develop these strategies, it is only in her autobiography and folk pedagogy that we find clues of the key sources from which she derived the knowledge and practices she was using effectively. Her autobiographical experiences of being a learner in a similar linguistic context, her own understanding of and interest in science, and learning from experience of teaching were found to be the key sources.

The teacher herself studied in a Telugu medium school up to her X grade and had faced great difficulty with English when she was shifted to English medium in her 11th grade. She recounted her experiences of her struggles to understand, as well as what enabled her to handle the challenge. All these struggles seemed to have convinced her of the necessity of meaning making to be central in learning, and the confidence to use Telugu liberally in this phase of learning. Fradd and Lee (1998) suggest that science teachers who share their students' languages and cultures are likely to relate in more meaningful ways to their students' prior experiences. While the teacher did not share the specific subculture from which the student's come (although coming from the same linguistic background and having had the same experience with medium of instruction, but from a higher socio-economic and caste group), there was also sufficient generic common cultural context of experiences for her to draw upon while she engaged the students in constructing their scientific concepts by relating to everyday experience.

The teacher had a B.Sc and M.Sc. and had also pursued a P.G. Diploma in Bioinformatics with the intention of pursuing a career in science. She had also taught at the undergraduate level in a science programme. However, on account of having to care for her small children she became a school teacher, and later acquired a B.Ed professional degree. This school was her second job and it has been six years since she joined here. She thought of herself, primarily, as a student of science. She was of the view that once anyone gets interested in everything around him, he will naturally understand that there is science everywhere. This seemed to inform her practice of connecting phenomena to everyday life and encouraging students to think and reason on their own. Her view that one should be able to independently give an answer rather than by rote, also seemed to be derived from the same view of what it means to learn science and how scientific thinking and knowledge should be an extension of everyday, independent cognition, even while it is eventually 'schooled' for the purposes of examinations. Her practices seemed to be aimed at achieving both of these, learning for understanding and for passing examinations, as aims of the school science curriculum.

The teacher had worked out strategies for bilingual instruction, balancing use of mother tongue and English. With constant code-switching, repetition, reasoning and cued-questioning mediation practices she was able to address the diverse

learners in the classroom. The relevance of such multilingualism for inclusive education has been noted by researchers (Agnihotri, 1995, 2010; Jhingran, 2012). Her code switching between everyday language (in Telugu or English) and scientific language also is consistent with observations of researchers who point out that for native speakers also, learning science involves not only learning the subject matter, but also learning a 'new' language (Halliday, 1989). Aikenhead (1996) describes the science classroom as a 'cross cultural event' for many students, and describes the process of learning as a 'border crossing' experience, between the student's life-world and the subculture of science. We notice in the case of our teacher, that this border crossing is the important one in learning science in the ESL context. The major effort is directed at enabling students to form an understanding in the mother tongue, trust this understanding and develop confidence, and use this to and 'latch on' to the critical terminology and 'grasp' scientific formulation to navigate the border crossing (Lemke, 1990). The ESL context itself seems to be secondary and de-emphasised, with the focus moving to enabling students to use the right language and terminology while answering questions in tests and examinations.

This study presents a case in which science was learnt meaningfully in an ESL-LEP context, and presented strategies that a teacher had evolved for this. These strategies, which were intuitively evolved by the teacher, relate well to strategies described in the literature for teaching science in such contexts. Thereby, it draws attention to the possibility that reflective engagement on autobiographical experiences, as well as understanding of the discipline play a critical contribution to the formation of this practice. Sarangapani (2018) has noted the need to make a distinction between institutions run by charitable organisations and those which are low fee paying catering to the similar population group, in terms of quality of education. In this case also it would seem that the teacher gained confidence to aspire for higher curricular goals for children from lower socio-economic groups, from the overall institutional context which gave her autonomy to develop her practice reflectively.—

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