Teacher training for secondary school (for language in science teaching): just because two-thirds of all talk in most science classrooms is by the teacher

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Implications of the Findings cont’d

Mentoring
- Collaboration between science/physics teachers, new and more experienced, and/or with teachers of other subjects and subject associations.

Teacher education curriculum
- A space for this may introduce a need to reorganise the teacher education curriculum, including the specific curricula of the teaching subjects.

In-service programmes
- Currently serving teachers never had this special preparation and may not be going through the experiences relevant to realisation of the importance of these words to students’ enhanced learning of science.

Need for further research
- on teacher educators’ conceptions of the nature of science, possible differences in approaches to teaching science by gender.
Introduction – The Concerns, The Focus and The Aims

• Research on the role and place of language of instruction in science education centering on South Africa has been a neglected area (Malcolm & Alant, 2004; Venkat, Adler, Rollnick, Setati & Vhurumuku, 2009; Vorster, Mayet & Taylor, 2013).

• In the global science education research arena similarly, there has been an enduring neglect of research channelled to bring about a better understanding of the impact of the language of instruction on science learning (Fensham, 2004; Oyoo, 2004; Roth, 2014; Yore, Bisanz & Hand, 2003; Yore & Treagust, 2006).

• This presentation is to share outcomes of analyses of data collected over a period of four years on an ongoing project [to cover the research void] where science learners’ understandings of meanings of selected everyday English words presented in a science context are being investigated as explorations of linguistic issues in learning and teaching science in South African schools.
• In South Africa, and partly because of the multilingualism policy in place in the country, there is a prevailing misunderstanding of the place of general proficiency in the language of learning and teaching [LOLT] [English/Afrikaans] generally (Vorster, Mayet & Taylor, 2013) in the successful learning of science.

• While evidence gleaned from transnational research conducted over the last 45 years suggests that the general difficulty of the LOLT science ‘is for reasons other than student levels of general proficiency in LOLT’, in South Africa, the place of proficiency remains overrated.

• The aims of project this presentation draws from and therefore this presentation is to create a better understand of the real origins of the language related difficulties that science learners in South Africa do or may be expected to encounter with the LOLT of school science in general and thus present a basis for away forward in this area.

A News Alert:

Intended Messages from this Address

• Science is a distinct language and science has its own language.

• Success in science is not only about learners being competent in the language of learning and teaching [LOLT]; learners must be intrinsically capable to handle the science concepts.

  “What kind of science can a child learn in the absence, for example, of basic language competence and an attendant inability to handle concepts?” (Achebe, 1990, p. 62)

• Science teachers/educators and science teacher educators generally lack awareness of the impact of the classroom language on science learning.

• The curricula used at initial and continuing education of science teachers need to be restructured to incorporate issues on the role of and nature of language of learning and teaching used in learning and teaching science.
Language use and Talk in Teaching and Learning

- The need for teacher intervention in learner acquisition of school science knowledge has been well articulated (Driver 1991).

- Infrastructure lack in most South African schools means teacher talk takes central stage during the teaching process.

- In effective teaching of science, teachers convey the ideas of science by trying their best to explain the concepts and operations clearly, make use of metaphors, use demonstrations and practical work to flesh out abstractions, utilize projects and discussions for involving students in the subject matter (Matthews, 1998, p. 9)

- Language use during practical work:

  ...meaningful practical work, whether by scientists or by children, is always embedded in conversation, - a discussion of ideas that makes it necessary to check those ideas against experience (Sutton, 1998, p. 174)
The Components of Teacher Classroom Narrative Trail – the Five Categories (Source: Scott, 1998, p. 56)

Teaching narrative

Major strands

Developing scientific knowledge

Supporting student meaning-making

Maintaining the teaching narrative

Forms of pedagogical intervention

1. Developing the conceptual line:
   - Shaping ideas;
   - Selecting ideas;
   - Marking key ideas

2. Developing the epistemological line

3. Promoting shared meaning

4. Checking student understanding

5. Maintaining the narrative
Teacher Talk in Teaching and Learning

• Drawing from observations of classroom interactions: Ned Flanders (1970)

• (a) for about two thirds of the time someone is talking;

• (b) about two thirds of this talk is the teacher’s;

• (c) about two thirds of the teacher’s talk consists of lecturing or asking questions.

• Edwards and Mercer (1987, p.25)
The instructional language in a science classroom has a non-technical component that on the other hand is made up of non-technical words, words which define or give identity to the particular Language of Learning and Teaching (LOLT) in use in a classroom or the language of a science text; this is to the extent that we are able to tell which language is in use, whether the language is isiZulu, English, Afrikaans or any other.
Technical terms – Science words/terminology/science concepts

**Technical Component** of the language of instruction comprises of technical words, words that are considered to define science content.

- Technical words include such things as physical concepts (*mass, force*...) names of chemical elements, minerals, plants, organs, processes, apparatus etc.

  Gardner (1972, p. 7)

  - **Consider the following words:**
    - Biology: Chromosomes, Zygote
    - Chemistry: Cation, Oxidation
    - Physics: Capacitance, Resistance

*In essence, learning or teaching school science is about mastery of this component of the science classroom language.*
The ‘Anatomy’ of the Science Classroom Language cont’d

- Words in a New Language
- Words in School Science
- Words in a New Culture
- Represent Scientific Concepts
Non-Technical Component is part of the science teachers’ classroom language that may be referred to as the medium of classroom instruction or interaction as separate from the technical terms. Also recognisable as the same as the language in which a science text book is written. This component consists of three distinct components:

1. Non-technical Words in the Science Context:

These words constitute the language typical of science subjects, e.g.

Diversity – Biology
Reaction – Chemistry
Disintegration – Physics

An illustration of non-technical words used in the science context:

“… gas molecules display random motion; we may predict their behaviour from theoretical considerations: the actual volume of the molecules may be neglected“ Gardner (1972, p. 7).

Functional value
2. Metarepresentational terms

- Metarepresentational terms are non-technical words that signify thinking; these are either metalinguistic or metacognitive words:
  - *metalinguistic verbs* are words which take the place of the verb to *say* (e.g. define, describe, explain, argue, criticize, suggest);
  - *metacognitive verbs* are words which take the place of the verb to *think* (e.g. infer, calculate, deduce, analyse, observe, hypothesize, assume, predict).


  - Functional value:
3. Logical Connectives

- Logical connectives are “words or phrases which serve as links between sentences, or between propositions within a sentence, or between a proposition and a concept” (Gardner, 1977a, p. v).

- Functional value:

- Examples include:
  - conversely,
  - if,
  - moreover,
  - because,
  - therefore,
  - in order to,
  - consequently,
  - by means of,
  - since, etc.
General Difficulty of Words in the Classroom Language

- All categories of words in the language of the science classroom/texts whether, technical or non-technical are generally difficult to science learners; this difficulty therefore presents the linguistic face of the difficulty of school science, i.e.

- **Technical words:** The general difficulty of school science, hence science content/science words as is well known worldwide, varying in extent depending on the specific circumstances in different countries (George, 1999).

- **Non-technical words:** Research studies have shown that all categories of words in the entire non-technical component of the instructional language used in science are also generally difficult to all learners irrespective of their gender, and linguistic or cultural backgrounds (Oyoo, 2014).
The South African Study

The focus is on the finding in many studies that all categories of words in the entire non-technical component of the LOLT science are generally difficult to all learners irrespective of their gender, and linguistic or cultural backgrounds, especially that in all the studies, the difficulty of these words has been linked only to the participants’ use of English as either their first or second language. The teacher, despite the necessary role in learning science has generally been left out.

Research Questions
The focus in this presentation is on the student component of the larger exploratory study where the following two questions were addressed:

• Do South African learners encounter difficulties with non-technical words when they are used in the science context?
• What are the sources of the difficulties with non-technical words when used in the science context?
Conceptual Framework – Words as Language and as Knowledge

• The prominence of words of/in a language (of science) is based on the argument by Postman and Weingartner (1971) cited in Hodson (2009, p.242):

• All of what we customarily call “knowledge” is language. Which means that the key to understanding a “subject” is to understand its language...what we call a subject is its language. A “discipline” is a way of knowing, and whatever is known is inseparable from the symbols (mostly words) in which the knowing is codified. (Postman& Weingartner, 1971, p. 102 in Hodson, 2009, p.242; colour and italics, my stress)

• Pragmatics
• This particular focus on language ascribes to Wickman & Östman’s (2002) pragmatic perspective on language where, as cited in Gyllenpalm, Wickman and Holmgren (2010), “the meaning of a word is its use and function in a specific activity” (p. 1155).

• This suggests a need for shared thinking towards a common understanding of the meanings of words in all contexts of use even where the users are from first language backgrounds with regard to the language of interaction or classroom instruction in classroom circumstances.
Methodology: Study Participants and Data sources

The participants were 715 Grades 10, 11 and 12 physical science learners [English Second language users] and respective educators/teachers [all qualified and experienced] drawn from 35 high schools in Johannesburg area, South Africa. Data were obtained over a four year period through a word test to learner participants followed by group interviews with the participant learners and face-to-face interviews with each physical science teacher.

- The word test had items presented as in the following format:

During some chemical reactions, heat is generated. This means that heat is
   A. produced
   B. gained
   C. is lost
   D. is not needed

The temperature of the liquid was constant. This means it was
   A. increasing
   B. decreasing
   C. not increasing or decreasing
   D. increasing and decreasing at different times
An outline of a student focus group and in-depth interview schedule included questions as in the extract below:

1. Is the word ............................................................familiar to you? If so when did you first encounter the word?

2. How often have you used this word?..............Where?...................................How?

3. How often do your teachers use this word in the science classroom?

4. You gave.........................as the meaning of this word. How did you arrive at this as the meaning of the word?
Data Analysis

• The word test items were marked against correct answers and then recorded in terms of frequency and percentages.

• The words that had turned out as the easiest as well as those worst performed were identified and used in the focus group and in-depth interviews.

• Student as well as teacher utterances during the interviews were recorded and transcribed, followed by content analysis of the transcripts to identify the possible reasons/student participants’ explanations of the difficulties of the word items, but informed by the conceptual framework.
**Findings: Scores on the word test items**

*Performance Analysis of each word*

Table 1: Percentages of incorrect responses per word as performed by the student participants

<table>
<thead>
<tr>
<th>Question number</th>
<th>Word</th>
<th>Percentage of incorrect responses (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Consecutive</td>
<td>9</td>
</tr>
<tr>
<td>2</td>
<td>Displaces</td>
<td>23</td>
</tr>
<tr>
<td>3</td>
<td>Limit</td>
<td>18</td>
</tr>
<tr>
<td>4</td>
<td>Prepare</td>
<td>20</td>
</tr>
<tr>
<td>5</td>
<td>Generate</td>
<td>21</td>
</tr>
<tr>
<td>6</td>
<td>Sensitive</td>
<td>58</td>
</tr>
<tr>
<td>7</td>
<td>Characteristic</td>
<td>20</td>
</tr>
<tr>
<td>8</td>
<td>Trace</td>
<td>35</td>
</tr>
<tr>
<td>9</td>
<td>Fundamental</td>
<td>18</td>
</tr>
<tr>
<td>10</td>
<td>Constant</td>
<td>3</td>
</tr>
<tr>
<td>11</td>
<td>Contract</td>
<td>14</td>
</tr>
<tr>
<td>12</td>
<td>Valid</td>
<td>11</td>
</tr>
<tr>
<td>13</td>
<td>Spontaneous</td>
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<td>Factors</td>
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<td>15</td>
<td>Concept</td>
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<td>16</td>
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<td>18</td>
<td>Effect</td>
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<td>19</td>
<td>Consistent</td>
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<td>Convention</td>
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<td>24</td>
<td>Disintegrate</td>
<td>13</td>
</tr>
<tr>
<td>25</td>
<td>random</td>
<td>11</td>
</tr>
</tbody>
</table>
Findings: Explanations of the difficulties with everyday words

SPONTANEOUS
The word appeared in the test in the form:
*The two chemicals seemed to combine in a spontaneous reaction. This means the reaction*
A. was very quick.
**B. happened by itself.**
C. once started increased vigorously.
D. was explosive.

All responses A, B, C, and D were selected in significant proportions.
Researcher: Has the word [spontaneous] been met in a science class?

S: I think I met it in physics where we were to calculate the velocity of a vehicle. Where we were to calculate the distance the vehicle had covered or rather the average velocity at which the vehicle was moving, but you can never find the exact velocity with which it is moving at a particular time but an average, meaning that the velocity was not constant but kept changing.

R: And that was spontaneous?

Ss: No! Instantaneous (chorused the other students in the group).
Evidence of encounter with the word ‘spontaneous’ in Chemistry:

S: When sodium [or potassium] was put on water, it started to, it moved on top of the water very fast, very quickly almost everywhere on the water surface. At the end of the reaction of sodium [or potassium] with water, the small piece of sodium [or potassium] that remained exploded (Emphasis added).

S: I think in chemistry there was confusion between whether it [spontaneous] is something that happens on its own and something that happens immediately and we would like to know the answer to that.
Encounter with the word ‘Spontaneous’ in physics:

S: The context in which I first met the word spontaneous was in physics when we did radioactivity and our teacher explained that in radioactivity, the emission of rays [radiation] just occurs spontaneously, so we took it that it is a process that takes place all over sudden. So in that context we got the impression that it is a reaction that takes place just suddenly, an explosive reaction. (S; Emphasis added)

Physics teacher: The word spontaneous is a very rare word especially in physics. I don’t use it in Form One, Form Two and Form Three though I use it for the first time in Form Four when I am teaching ‘radioactivity’ in physics. But again when we are teaching, of course, we may just teach [mention] it in definitions like when defining the term ‘radioactivity’. This word [spontaneous] appears in that definition. (T1)
SENSITIVE

In the word test, *sensitive* appeared as:

*The beam balance is a very **sensitive** instrument. This means that it*

A. *can be used to weigh very small things.*
B. *can be used only by sensible people.*
C. *is hard to understand how it works.*
D. *gets spoilt very easily.*

This word attracted only two categories of responses; either that a *sensitive* instrument “*can be used to weigh very small things*” (42%) or that it “*gets spoilt very easily*”. The portion of the study sample that selected D: “*gets spoilt very easily*” was 58%.
Sensitive cont’d

S1: I was disturbed by that word. I did it last. When we talk of *sensitive*, we talk of a sensor. You can also look at it as a delicate thing, you play around with it, and you spoil it. I got stuck somehow and then I ruled out its use to weigh very small things because ‘does it mean it cannot be used to weigh big things?’ So even now I don’t know the meaning of the word.

S2: This word was used interchangeably because when something is *sensitive*, it in many cases means that the instrument *can be used to weigh small things* but at the same time, when somebody says that the instrument is *sensitive*, it was meant to warn you not to touch a particular thing because it *can get spoilt very easily*; so the word was ambiguously used.

S3: To me sensitivity means the reaction of something; was *sensitive* in that if the student did not handle the beam balance correctly, it would give a wide range of values. So I tend to support the view that it means that it is *sensitive* in weighing small things.
S4: Some teachers could say (with emphasis) that ‘this instrument is very sensitive’ and that one made some students to even fear to handle the apparatus. They should have approached it by referring to the function of the instruments instead.

Physics Teacher: I have never explained the word ...sensitive to them; I have always assumed that they know the meaning.... You see the word sensitive in physics does not mean the same thing as in normal language. It means an instrument that can detect small values but I have never actually explained it. I have always assumed ... (T6)
Findings: Teachers’ General Opinions on Words Use

• Flowery language goes against teaching science since it will make learners not get the feel of what science is. ... Science language gives little latitude for use of a lot of English words. ... The science teacher has no time to explain the English words as this is best explained in English lessons; the teacher has to be simple though. (T4, Emphasis added)

• I believe that in every lesson there is a word that goes unexplained which in my belief is simple and assume they know the meaning and I believe that many of us science teachers still don’t explain words and expressions... (T1)

• Many teachers don’t explain these things not because they don’t want to... it is not their fault; they also think ... the meaning is normal and if it is put like that in our textbooks, then every person should just understand.... (T1)
Conclusions and Implications of the Findings

• The total findings in this study:
  • enables a recommendation that urgent steps need be taken to help teachers and teacher educators to recognise that everyday words cease to be mere words of the LOLT when used in the science context.
  • strongly suggests that focusing on contextual proficiency more than on general proficiency in LOLT during teaching perhaps holds more promise for enhanced learner outcomes in science.
Teacher classroom practice – Teachers need to be encouraged to take more cognisance of the functional value of the non-technical words in the science teachers’ language, e.g.

- the teacher should or may have .. own dictionary of ... words that are basic in science and that should be given to the students and explained. So as students come in Form One, you look into the Form One syllabus, Form One coverage and extract words and expressions that ...should be known by these students. So during ...lessons when ...using such words ...take a moment to give just a deeper meaning of that word so that when they use it later they use it correctly. ... what I am saying is that ... a teacher should have a small dictionary of own words that are controversial. (T1)

- also like in English language, they usually have a list of most commonly mis-spelt words. The teacher should also come up with the most commonly misunderstood words, words with which there have been time and time again, a problem when used by the physics teachers in the science context (T6).
• **Mentoring** - Collaboration between science/physics teachers, new and more experienced, and/or with teachers of other subjects and subject associations external to the school.

• **Teacher education curriculum** - A space for this may introduce a need to reorganise the teacher education curriculum, including the specific curricula of the teaching subjects.

• **In-service programmes** – currently serving teachers never had this special preparation and may not be going through the experiences relevant to realisation of the importance of these words to students’ enhanced learning of science.

• **Need for further research** – on teacher educators’ conceptions of the nature of science.
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