



Facilitating Conceptual Change in Teachers: A Study

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Abstract

This paper describes the rationale for [and evaluates the effectiveness of] a practice adopted by a science teacher educator. In choosing to teach science for conceptual change to forty teachers, this teacher educator considered socio-cultural influences, the epistemology of science and the vision of the organization. An attempt to effect conceptual reorganization and change in forty teachers has been described and its impact evaluated. Teachers were simultaneously exposed to the pedagogy of teaching science for conceptual change. Analyzing baseline, mid-line and end line data of teachers' conceptual understanding, an upward trend indicates a better grasp of all concepts, with a loosening of their grip on prior misconceptions. The extent of shift in teachers' understanding is viewed against the backdrop of current research on conceptual change. Reasons for the success of the teacher educators' practice are analyzed along with key implications for teacher education in similar contexts.

Introduction

Azim Premji Foundation is a not-for-profit organization aiming to contribute to a just, equitable, humane and sustainable society, by facilitating deep, large scale and long-term impact on the quality and equity of education in India. This paper describes and evaluates a practice adopted by a Science teacher educator in training teachers of Azim Premji Schools.

Broadly, three factors had to be considered by the educator:

- Socio-cultural: In India, respect is to be accorded to elders, and particularly to the teacher. A mark of 'respect' is quiet acceptance of the teacher's words. A common approach adopted by teachers is one of *transmission of information* [Yashpal Committee 1993]. Mostly, teachers' knowledge of many subjects is restricted to reproducing facts from the textbook [Krishna Kumar 1988].
- Epistemology of Science: Being a discipline that is inextricably entwined with rational enquiry and logical reasoning, the need to expose teachers to these characteristics of science (teaching) was felt.
- Vision: Teacher education practices adopted by teacher educators of the organization have to necessarily disallow 'teaching to' teachers, as an individual cannot examine social structures critically if (s)he is not reflective.

Further, the need to enrich teachers' content as well as pedagogy prompted the educator to *Teach for Conceptual Change* in this workshop.

Background

Conceptual change is a research agenda that evolved from the alternative conceptions movement that expanded during the 1980s [Wandersee, Mintzes, & Novak, 1994]. The conceptual change approach has been used as a teacher education practice [Angela Ho, David Watkins and Mavis Kelly (2001) and references cited therein], dealing more with conceptual change in teachers' understanding of *pedagogy* than on their understanding of *content*. This prompted us to initiate conceptual change – in teachers' *understanding of the subject*. Hernandez, Buzzo and Rivera [2008] showed improvement in teachers' conceptual change in Physics concepts, before and after a workshop - through interviews and tests.



In science education, simply changing a particular belief or learning something new cannot necessarily be termed *conceptual change*. Replacement of one concept by another has been likened by Strike and Posner [1992] to Kuhn's 'paradigm shift' [1970] and Piaget's 'accommodation'. When students can grasp new phenomena *using existing concepts*, they term it 'assimilation'. A common thread running through several theories is the perception of *two kinds of conceptual change*, one more major than the other. These have been termed differently: assimilation and accommodation [Strike & Posner, 1992; weak restructuring and strong restructuring [Carey, 2000], conceptual capture and conceptual exchange [Hewson & Hewson, 1992], enrichment and revision [Vosniadou, 1994] and conceptual reorganization and conceptual change [Chi and Roscoe, 2002]. For the purpose of this study, we have used the **last-cited** theory.

Chi, Slotta and deLeeuw [1994] state: "...entities in the world may be viewed as belonging to different ontological categories." These categories could be – amongst others – Matter [things], Processes and Mental States. While sub-categories are also embedded within each of these "trees", Chi et al define conceptual change as the *reassignment of a concept from its initial tree to a different tree*. For example, electric current is not Matter, but a Process. Chi and Roscoe [2002] go on to argue that "this process is difficult if students lack awareness of when a shift is necessary and/or lack an alternative category to shift into." In contrast to their definition above of *conceptual change*, they describe the *repairing of preconceptions as conceptual reorganization*. Repairing preconceptions involves *conceptual reorganization*, while repairing misconceptions demands *conceptual change*. The impact of an attempt to effect both changes is studied here.

Methodology

A two-day workshop was conducted for 40 teachers. The three instruments - worksheets, interviews and questionnaires - and 4 probes (NSTA worksheets [National Science Teachers' Association] [Keeley, Page and Tugel, Joyce 2005] used are described below:

Worksheet	<i>Is it Matter?</i>	<i>Objects & Temperature</i>	<i>Can it reflect Light?</i>	<i>Rusty Nails</i>
Work involved (with rationale also)	Tick only those items (e.g. salt, electricity, love, etc.) that are matter.	Guess if temperatures of four objects (made of wood, glass, metal and wool) placed in the same room will be equal or different.	Tick those items which reflect light - for commonly, reflection is thought to imply shininess.	Guess if rusted nails will be lighter/heavier/same weight as clean nails - eliciting the misconception that rusting means decay.
Conceptual Change	<i>Revisit the categorization of listed items and therefore, its basis.</i>	A <i>conceptual change</i> is undergone in shifting 'heat' from 'substance' to 'process', according to Slotta et al [1995] – this was further affirmed by explicitly posing the	The <i>process</i> of reflection of light remains categorised as such, without a lateral shift to another ontological category.	No demand to transfer the <i>Process</i> of Rusting to a different ontological category like <i>Matter</i> , but reorganization of the <i>Process</i> under a sub-category – one which causes an <i>increase</i> (rather than a <i>decrease</i> or <i>no change</i>) in weight.



		question (in the endline) of whether heat and temperature are different.		
Experiment	Simply mulled over picture cards of each item in the list.	Measured the temperature of the listed objects with a thermometer.	Shone light on the listed objects with a flashlight.	Given twenty clean nails (of roughly equal weight) and another twenty that had been rusted earlier, compared the average weights of four clean/rusted nails. The rust fell off many during transportation to the venue - resulting in lower weights of rusted nails! This had interesting consequences - discussed later.

We submit that these worksheets can provoke the respondents to *revisit*, *reorganize* and *differentiate* their conceptions, and - in the case of *Matter* and *Temperature* - actually *change* them. However, as Slotta et al [1995] have shown, it is difficult to ascertain definitely *when* conceptual change has occurred.

Data Collection

The teacher educator began by sharing Watson & Kopniecek's [1990] *Teaching for Conceptual Change*, where Deb O'Brien confronts fourth graders' notion of heat and temperature. Thereafter, teachers answered the worksheets, yielding **baseline data**. Teachers then had to convince a colleague *who had entered different responses*, when their rationale was articulated. Thereafter, they experimentally tested their (*changed or unchanged*) understanding. **This was a step deliberately introduced by the educator**. After experimentation, any articulated change in their initial concepts was collated as **mid-line data**. On the next day, teachers exhibited greater tentativeness, with the previous day's experiences having shaken some of their prior beliefs. All principles were now explained to them by the educator. One month later, sustained change in their understanding was measured to give **end line data** (in contrast to Hernandez et al's [2008] study, where the extent of conceptual change was tested *immediately after* the workshop.) Each of the four probes was unpacked with ten ('true' or 'false') statements – designed to probe **two aspects** of their understanding:

1. **Grasp** of the *key principle*
2. **Shift** from *prior misconceptions*.

Results and Discussion

Three categories were used to code the initial responses of the forty teachers: **got/not got the concept**, and **confused understanding**. Ticking correct options - while articulating inadequate grasp of the fundamental principle in the rationale - was noted as '*confused understanding*'. Figure 1 shows



that the concept which more than 50% teachers had grasped at baseline was *Temperature* - perhaps because that was the subject of the paper shared at the start. More than 50% teachers started off believing that the weight of nails would decrease upon rusting. By midline (Figure 2), a fourth category appeared, with some teachers admitting to a **shift in their understanding**. Maximum *not got concept* responses were obtained for *Matter*. This could be because *Matter* demanded an ontological shift from one category to another, an act many researchers have deemed difficult [Slotta et al 1995]. Further, no experiment was performed for *Matter*. In contrast, a significant shift was seen for *Light*, with teachers actually observing light bouncing off the objects.

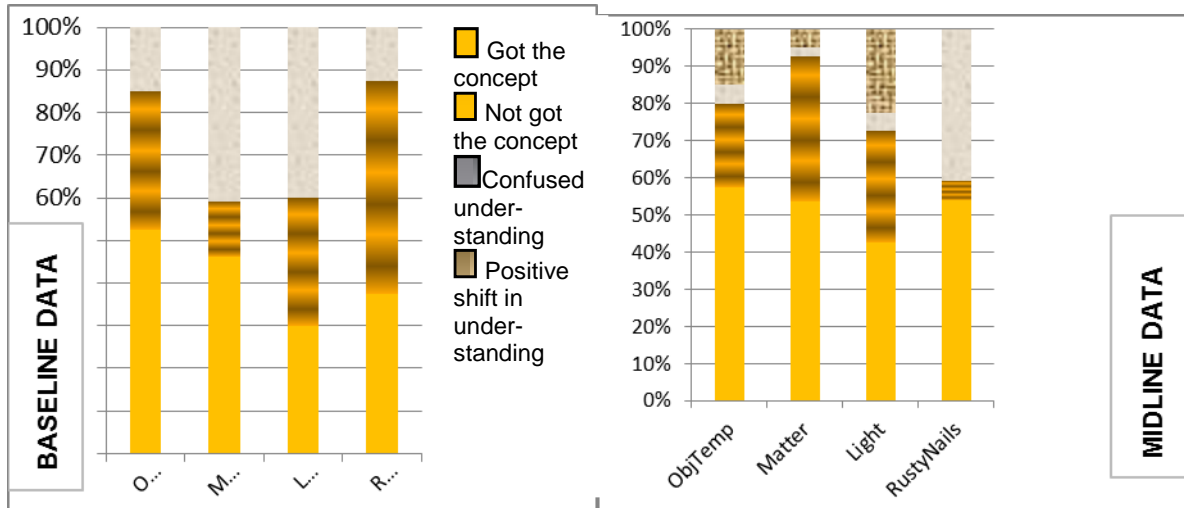


Figure 1 % age of Teachers vs Baseline Responses

Figure 2 % age of Teachers vs Responses Post Experiment & Discussion

By the **endline**, Figure 3 shows that the teachers' **understanding of the key principle** underlying all four concepts went up significantly:

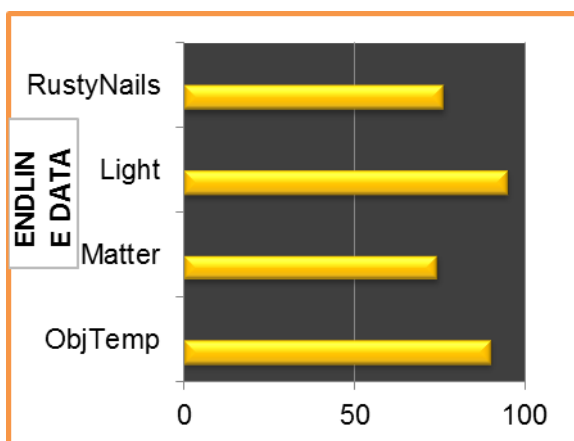


Figure 3 % age of Teachers vs Responses to Key Principle

Figure 4 % age of Teachers giving correct response to 4 key principles across the study

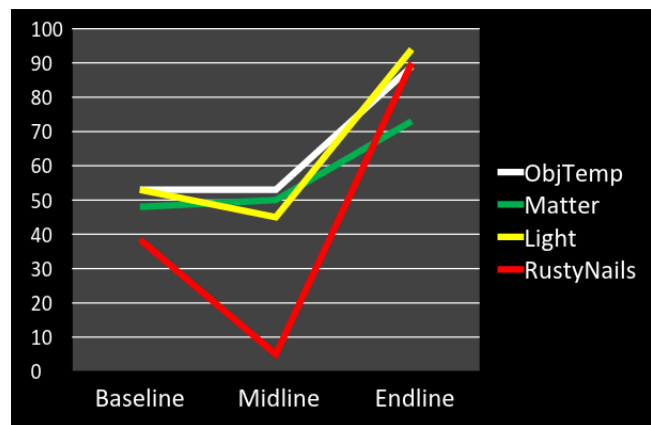
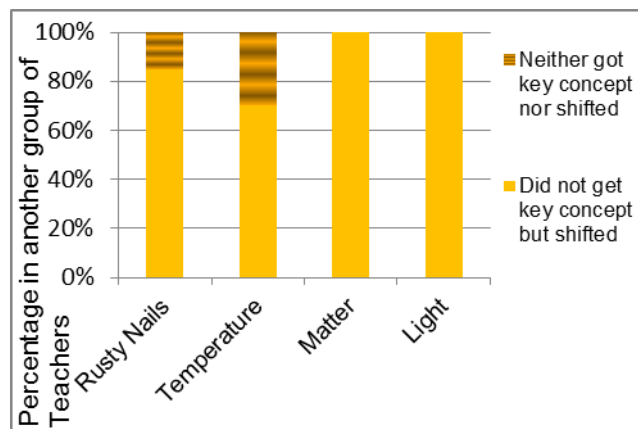
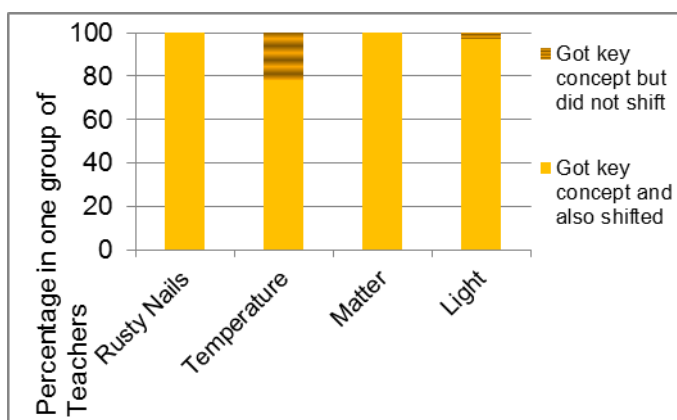


Figure 4 shows an **overall upward trend** in understanding of **four key principles**. Regardless of the correctness/incorrectness of their prior ideas, experimentation seems to have made teachers re-



examine them seriously. Naturally, the understanding of teachers dipped to the maximum extent for *Rusty Nails*. Confronted with a drop in weight after rusting, many got confused – which spurred *more than one teacher to go back later and repeat the experiment, browse the Internet or ask an expert*. Did ‘getting the key concept’ necessarily imply release from prior conceptions? Data for **two groups** of teachers is shown: one which grasped the key concept (Figure 5) and another which did not (Figure 6). Results imply **a state of flux in teachers’ understanding**: without yet having totally grasped the correct principle, most seem to have let go of their old notions - indicating **a gradual shift in thinking**. Literature corroborates this: Caravita and Halldén [1994] use the term “flickering status of conceptions”. Several misconceptions articulated at the start of the workshop did not seem to linger for more than 90% teachers by the end. The increase in weight after rusting was least understood.

Figs 5 & 6 Percentage of Teachers who got/did not get the key concept, and shifted/did not shift from prior conceptions



Conclusion

The understanding of teachers in all four concepts was strengthened - implying a fairly effective pedagogy - *without a total disappearance of prior concepts*. Examining *the reasons for successful shift* could enable appropriate choice of teacher educators’ pedagogy: (1) Circumvention of direct questioning of teachers’ knowledge: allowing teachers’ current understanding to emerge – *without immediate evaluation of the same*. (2) Coupling the worksheet with peer-to-peer-discussion: allowing teachers to confront others’ understanding - and revisit their own. Subtly, this shifted their expectation of learning *from the educator to learning from each other*. (3) Experiments following worksheets: Without this, such a shift may not have been observed. *Increased confusion* of many concepts *after* performing experiments helped disengage their grip on prior beliefs, opening them to the explanation that was then offered. A teacher education practice that broadly possesses these three characteristics is likely to succeed in similar socio-cultural contexts. By first facilitating teachers towards a sound conceptual understanding, a gradual impact on teachers’ pedagogy can then be envisioned.

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