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# A Longitudinal Study of a New Science Teacher's Beliefs and Classroom Practices*

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## Abstract

Teachers' educational beliefs influence their decisions and actions before, during, and after class. Classroom actions are a result of decision-making processes wherein teachers judge how they can teach effectively. The early years of teaching profession is important in shaping new teachers' practices in accordance with their beliefs. This study identifies how the beliefs and classroom practices of a new science teacher change within the first three years of working. This study's participant was a new high-school science teacher in Midwestern United States. Changes were investigated by employing qualitative research methods. Data for this longitudinal case study were gathered from interviews, questionnaires, and classroom observations for three years. The findings show that teachers cannot practice their reformist beliefs without experiencing real class environments.

**Keywords**: epistemological beliefs; new science teachers; pedagogical beliefs; teacher beliefs

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## INTRODUCTION

Becoming a successful teacher is a long and difficult process. What teachers experience through their training and how this experience affects their classroom practices has been the subject of numerous recent studies (Akkoç & Ogan-Bekiroğlu, 2006; Fletcher & Luft, 2011; Luft & Roehring, 2007; Wallace & Kang, 2004). Any act made by a teacher in the classroom is what seems to be the most logical thing to do for the teacher at that particular time and this act originates from teacher's epistemological and pedagogical beliefs (Tobin, 1990). There is a continual and reciprocated interaction between teachers' experiences at school, particularly, in a classroom and their epistemological and pedagogical beliefs that are shaped during the first years in the teaching profession.

Certainly, the initial years in the profession make up an important and critical period in the teacher's development and, therefore, continuously shape their professional beliefs and practices (Feiman-Nemser, 2003). Additionally, any changes to teaching that may have been enacted to help teachers adapt to their profession, are only really valid on paper and are insufficient in ensuring the success of educational reform. As that change and adaptation largely depend on 'what teachers think and do' (Fullan, 2007, p. 129), their initial years provide an understanding of their profession and help them to decide future roles they will undertake.

There is a new generation of teachers who strive to adopt a basic philosophy that underlies new approaches concerning the nature of science and the way of teaching science as inquiry (Authors, 2015). However, problems may arise when these teachers start their jobs and join other teacher community of practice who are distant from these new approaches. As it is now and will be in the future, a community of teachers that adheres to traditional approaches may negatively influence the principles and classroom practices of those who are trained in constructivist paradigm. In fact, eventually they may influence the new teachers. Thus, instilling schools with new ideas, reforms, and practices that have gained global momentum becomes difficult and is possibly even doomed to failure (Cuban, 1990; Haney, Czerniac, & Lumpe, 1996; Lumpe, Haney, & Czerniac, 1998). However, the scenario may not always be that bad. Teachers may also come across a social group with the same philosophy in their schools. But is this enough to transfer their beliefs to the class? Therefore, the purpose of this study was to delineate how a new science teachers' belief and her classroom practices adapt over time in a social teaching environment.

### Theoretical background

Teachers' understandings of learning environment is the reflection of their beliefs about education, teaching and learning (Authors, 2011; Authors, 2013; Bogar, 2019; Water-Adams, 2006). Ajzen and Fishbein (1980) define belief as the sum total of the ideas of individuals regarding another person, a group of people, a behavior, or a specific event. Rokeach (1968) argues that until a specific level of maturity has been reached, people may have almost thousands of ideas about what is right or wrong or what is good or bad in the physical and social world. Under the influence of such beliefs, individuals' acts are demonstrated through different mechanisms of the intellect such as the decision-making process. Thus, it becomes easy to demonstrate these acts but difficult to give them up when one considers that their roots, which are beliefs, are strong.

Teachers' beliefs influence their decisions before, during, and after class. Learning environment of the class is depends on the decision-making processes of the teacher who judges what should be done in order to teach well. Rokeach (1968) mentions that these beliefs should be addressed at a level that extends from the center to the periphery. He refers to central beliefs when there is a consistency between belief and practice, but to peripheral beliefs when there is an inconsistency between the two. He further states that central beliefs are more resistant to change than peripheral beliefs that are relatively open to modification. Haney and McArthur (2002) developed a model on the basis of Rokeach's (1968) idea that there are at least two types of beliefs that influence the decision-making process related to the act to be demonstrated. In their model, which also inspired the authors of

this study, Haney and McArthur (2002) further re-define central and the peripheral beliefs regarding the teaching context. The authors categorized pedagogical beliefs into two; constructivist beliefs (referred as reformist) aligning with Taylor, White and Fraser's (1994) perspective and conflict beliefs are those beliefs in opposition to constructivism. The authors then established their own structure by placing these beliefs either in central or peripheral category. That is to say that, if a teacher adheres to a belief associated with constructivist philosophy and engages in its related practices in his or her classroom, one could consider that this teacher holds constructivism as his or her central belief. In their definition of peripheral beliefs, Haney and McArthur (2002) argue that somebody who holds a constructivist perspective but does not engage in its related practices in class, or, perhaps, vice versa, is somebody with a peripheral belief. An example of this would be when teachers believe that 'students must generate arguments to test alternative explanations with each other' but fail to provide a class environment where this may actually happen. As a result, they pedagogically formed three categories; (1) constructivist belief and constructivist action (2) traditional belief and traditional action and (3) constructivist belief but traditional action.

In their studies, Akkoç and Ogan-Bekiroğlu (2006) and Ogan-Bekiroğlu and Akkoç (2009) worked with prospective physics and mathematics teachers to examine the relation between their pedagogical beliefs and actions during school practicum. However, they identified teacher profiles that did not exist in the analysis of Haney and McArthur (2002). For example, in their model, it was impossible to categorize a teacher who holds transitional pedagogical beliefs (to have constructivist and traditional views at the same time) and engages in constructivist practices such as those identified by them. Thus we can categorize pedagogical beliefs as constructivist, traditional and transitional. When we combine these teacher beliefs with different teacher actions it is possible to reach six different teacher profiles (3x2). All possible combinations were; constructivist-central, constructivist-peripheral, transitional-central, transitional-peripheral, traditional-central, and the traditional-peripheral for the relation between pedagogical beliefs and classroom practices.

This research, consisting of a longitudinal case study, seeks to develop our understanding about how the original beliefs and classroom practices of new teachers, who are crucial actors in educational reform, can change over years. It seeks to address how and why these practices and beliefs change after teachers actually start teaching by considering the beliefs and practices of a specific teacher over a time scale of three years. The participant teacher of this study was selected from a project (XPROJECT) which was launched in XXXX by Authors and colleagues. The XPROJECT was a multi-university collaborative research study that investigated the longitudinal impact of science teacher education programs for middle and secondary teachers and their students across the critical developmental stages of the teacher professional continuum (Authors, 2013).

After checking the validity of the model that was developed by Haney and McArthur (2002) and revised by Akkoç and Ogan-Bekiroğlu (2006) to help relevant analyses and by tracing the changes in a teacher who had just started teaching, the following research questions guided this study:

1) How do the pedagogical and epistemological beliefs and classroom practices of a first-year science teacher change over time?

2) Do the changes of the teacher's pedagogical and epistemological beliefs and classroom practices consistently correspond with each other?

## METHODOLOGY

Qualitative research methods were utilized to describe complex structures such as experiences, beliefs, and the way in which these translate into practice. Additionally, detailed demographical information about the participating first year science teacher was also collected. A longitudinal case study research design was used to track in detail the adaptation process of a new science teacher into the new professional environment (Holland, Thomson, & Henderson, 2006). The rationale for this

type of design is that it allows the researcher to better understand the evolutionary process of different changes as well as their different circumstances over a long duration.

**The Participant**

The participant, Tanya, was a science teacher who taught in Midwestern United States and was in the first year of her profession. In her interviews, Tanya indicated that at the university, she primarily studied psychology, but she tried to take as many science modules as she could during this time. Tanya had gained some experience with post-school young adults at youth centers. After working as a school guidance teacher, she felt happy while engaging with students in class, and thus, decided to continue her career as a science teacher. When asked to define the school environment in which she started the profession, she emphasized that her mentor, other teachers and administrators in the school were likeminded with herself during the three years. In this context, Tanya stated that she did not encounter any negative external factors while conveying her thoughts to the class.

**Data collecting instruments and procedures**

To investigate the research questions, three instruments were used to gather data on Tanya's epistemological and pedagogical beliefs along with her classroom practices. The instruments were *Beliefs and Nature of Science Interviews* (BNOS), *Beliefs about Reformed Science Teaching and Learning* (BARSTL), and the *Reformed Teaching Observation Protocol (*RTOP). Her epistemological beliefs were identified through the BNOS protocol. In line with the aims of the XXXX project, the relevant questions from the 'Teacher Pedagogical Philosophy Interview' developed by Richardson and Simmons (1994) were selected. The interview protocol consisted of 13 questions. Seven questions were about teachers' pedagogical beliefs and six questions were about their epistemological beliefs (Authors, 2013). In addition, the BARSTL scale was utilized to discover the participant's beliefs about defined dimensions and obtain information on other issues that could not be extracted from face-to-face interviews. BARSTL was developed by Sampson and Benton (2006) with the aim of mapping the teachers' beliefs in relation to the process of teaching and learning between the traditional-reformist sides in the context of current reform initiatives in science education. The instrument involves of 32 questions that "can be used to assess the degree to which science teachers' beliefs about teaching and learning of science align with the current reform movement in science education" (Sampson & Benton, 2006, p.5). The last instrument used to evaluate the classroom practices of teachers was the RTOP developed by Sawada et al. (2002) under the Arizona Collaborative of Excellence in the Preparation of Teachers project. Following this protocol, video records of teachers in their classes were analyzed to investigate whether the identified beliefs of teachers were in conformity with their classroom practices. The protocol consists of 25 items. Data was collected for three school years. Following the schedule set, face-to-face interviews (BNOS) were conducted in the fall of each year for periods of about 1 to 1.5 hours. After these interviews, the participating teacher was visited on one occasion without prior notification so that her class sessions could be observed and recorded. The BARSTL scale was also given to Tanya once a year just after the face-to-face interviews were conducted.

**Data Analysis**

The four dimensions concerning inquiry-based teaching (see Furtak, 2006 and Authors, 2015 for further details) were used to analyze the participant's beliefs and classroom practices in the context of inquiry-based teaching strategy. The identified methodological, conceptual, social, and epistemological dimensions by the (Furtak 2006) guided the direction that the analyses should follow. During the analysis, common themes (sub-dimensions) emerged from the literature of the field together with the aspects of the scales used in the survey were placed under these dimensions, as shown in Table 1. The themes that were identified by analyzing the methodological dimensions were *science process skills, teacher profile, teaching methods,* and *evaluation.* While the conceptual dimension encompassed the theme of the *learning approach*, the social dimension comprised themes

such as *student–student interaction*, *shared control*, and respect to *alternative ideas.* These three dimensions were used as the commonality in analyzing both beliefs and class practices. As to the epistemological dimension, it covered six themes, namely, definition of science, tentativeness of scientific knowledge, scientific method, role of experiments in science, theory and laws, and science–society relation.

**Table 1: Dimensions and themes emerged from literature and used in the analysis**

| Dimensions | Themes |
|---|---|
| Methodological | Science Process Skills<br>Teachers' Profile<br>Teaching Methods<br>Evaluation |
| Conceptual | Learning Approach |
| Social | Student–Student Interaction<br>Shared Control<br>Respect to alternative ideas |
| Epistemic | Definition of Science<br>Tentativeness<br>Scientific Method<br>Role of Experiment<br>Theories and Laws<br>Science–Society |

The interview analysis maps, as developed by Luft and Roehring (2007), were used to analyze the participant's beliefs about learning, teaching, and the nature of science. While the themes regarding the pedagogical beliefs and classroom practices were identified as reformist, transitional, and traditional, epistemological beliefs were categorized as informed, eclectic and naïve. Data triangulation was achieved by using different data sources (Patton, 2001) such as, semi-structured interviews, participants self-reports via BARSTL survey and observations. Transcripts from interviews were carefully examined and searched for evidence to all themes in the study. As shown in Table 2, all BNOS, BARSTL and RTOP questions were classified and assigned to a related theme for analyzing process. For example, in order to analyze "teachers' profile" theme, participants' self-declared BARSTL statements numbered 22, 23 and 24 were used along with the answers on the question "How do you describe your role as a teacher?" in the BNOS interview protocol. Items 23, 24 and 25 in RTOP protocol were used to determine teachers' actions in the classroom concerning the same theme. As an example, item 25 in RTOP observation protocol "The metaphor 'Teacher as Listener' was very characteristic of this classroom" was used as evidence to identify teachers' profile in action.

**Table 2: Related questionnaire items used for analysis of themes**

| Themes | Related BNOS Questions | Related BARSTL Items | Related RTOP Items |
|---|---|---|---|
| Science Process Skills | - | 7, 9, 11, 12, 30 | 4, 11, 12, 22 |
| Teachers' Profile | 2 | 22, 23, 24 | 23, 24, 25 |
| Teaching Methods | 1, 6 | 13, 26 | 6, 9, 13, 17 |
| Evaluation | 5, 3, 7 | 16 | 3, 14 |
| Learning Approach | - | 1, 2, 4, 5, 6, 10, 25, 29 | 1, 7, 8, 10, 21 |
| Student–Student Interaction | - | 8, 14, 17, 18 | 16, 18 |
| Shared Control | 4 | 20 | 2, 5, 19 |
| Respect to alternative ideas | - | 15, 19, 21, 28 | 15, 20 |
| Definition of Science | 8 | 3 | - |
| Tentativeness | 10 | - | - |
| Scientific Method | 9 | 27, 31 | - |
| Role of Experiment | 11 | - | - |
| Theories and Laws | 12 | - | - |
| Science–Society | 13 | 32 | - |

Note: Data from BNOS interview used as evidence for all themes.

Similarly, by using the BARSTL scale, the teachers' responses were classified as 'reformist' if they were aligned with constructivist perspective, 'traditional' when they are not reform-oriented, and 'transitional' when no clear idea was stated. Lastly, when evaluating videos of class practices on the basis of the RTOP scale, the scores ranging from zero to two were assigned depending on the frequency of the realization of the related proposition. Participant teacher was classified as '2-reformist' if she was engaged in relevant constructivist practices in her class (if the action is very descriptive), '0-traditional' if her practices were not reformist (if action never occurred), and '1-transitional' when she was not consistently engaged in reformist practices. Additionally, in order to improve the consistency of coding and achieve interrater reliability data was analyzed and coded by two trained coders separately (Patton, 2001). The coders compared their analysis in an iterative process until convincing each other on differences and achieve a 100% consensus. After all data sources were analyzed and categorized separately then we looked for the coherence of the aspects.

## FINDINGS

Initially, we examined Tanya's pedagogical beliefs that were both central and peripheral. We then proceeded to examine her epistemological beliefs. The extent to which she conformed to these beliefs and practices are presented below by years. The findings are summarized in Table 3, 4 and 5 for each year. Tables present teachers' pedagogical beliefs with the '●' symbol and classroom activities with the '○' symbol. As an example in Table 3, Tanya's performance about *shared control* theme in first year was reformist in order to beliefs (there is a '●' symbol as seen on the reformist column on the right-hand side) and traditional in order to classroom practices (there is a '○' symbol on the traditional column). If these two symbols coexist (◉), the table should be read as the belief and practice are nested as seen in *learning approach* theme.

### Year 1

### Central Beliefs

After evaluating Tanya's first year of teaching, it was observed that she held central beliefs but only around the conceptual dimension (Table 3). Tanya expressed reformist views for all of the seven propositions under the conceptual dimension of the BARSTL scale. In responding to these propositions, Tanya stressed the importance of students' having prior knowledge of a topic, keeping them intellectually active rather than just receivers of a subject that is directly conveyed to them and attaching importance to the quality rather than the quantity of concepts that are covered.

**Table 3: Beliefs and classroom practices of Tanya in her first year of teaching**

| Dimensions | Themes | Traditional | Transitional | Reformist |
|---|---|---|---|---|
| Methodological | Science Process Skills | | ○ | ● |
| | Teachers' Profile | ○ | ● | |
| | Teaching Methods | | ○ | ● |
| | Evaluation | ○ | ● | |
| Conceptual | Learning Approach | | | ◉ |
| Social | Student-Student Interaction | ○ | | ● |
| | Shared Control | ○ | | ● |
| | Respect to Alternative Ideas | ○ | | ● |
| Epistemological | | Naive | Eclectic | Informed |

● pedagogical beliefs
○ classroom practices
◉ nested pedagogical beliefs and classroom practices

Using the RTOP scale to evaluate Tanya's teaching practices during her first year, we again see a reformist approach in terms of the different components of the conceptual dimension. When introducing the topic of chemical compounds, for example, Tanya tried at the beginning of the class to explain chemical relations using human relations as a metaphor. She tried to show the outcome of two

compounds being joined together and then separating by drawing an analogy to two lovers in a relationship. In other words, Tanya tried to facilitate learning by utilizing information from the real world with which students may be familiar. She also used demonstrations in class to present the topic to students while offering examples from nature (HCL+ zinc). Therefore, Tanya's beliefs and classroom practices were consistent in respect to conceptual learning.

**Peripheral Beliefs**

Looking at the issue as a whole, practices related solely to the dimension of conceptual learning being proved insufficient in creating the desired learning environment. Considering the other dimensions identified, Tanya could not repeat the same success in terms of conformity between beliefs and practices. For example, during one-to-one interviews about the teaching methods employed by Tanya as a component of the methodological dimension, she replied in response to the question 'how do you maximize student learning in courses?' by answering as follows:

> Through cooperative learning… even when I give them working sheets to write formulas on, I want them to do it by working with their desk mates. Each has his laboratory partner and they are free to walk around …

In her class, Tanya was observed as making demonstrations and using a single-direction teaching method seeing that she gave answers herself without giving enough time to students when she asked questions. Tanya said she definitely agreed with the propositions under the social dimension of the BARSTL scale and upheld the principle that teachers should encourage their students to develop alternative ideas in class and provide an environment in which they can speak and discuss. Certainly, she displayed the firmness of her belief in this point by responding 'I completely disagree' to the diverting question of 'Students should work as independently as possible, this will make them learn not to shift their burden to others.' In practice, however, the lesson mostly comprised the teacher giving a lecture. During the class session, the only real type of communication was between the teacher and the students who tried to give short answers to the teachers' questions. There was no interaction among the students.

**Epistemological Beliefs**

The interview with Tanya revealed that in general, she held informed epistemological beliefs during her first year. For example, when asked about her ideas concerning the tentativeness of scientific knowledge, which is one of the themes identified in this dimension, her response was informed by her affirmation of the tentativeness of scientific knowledge. In her words, 'The fine thing about science is that it is in a continuous process of change; there are people out there constantly asking questions and each of these people may offer you a different perspective.'

Responding to another question related to scientific method while in her first year of teaching, Tanya said that she did not use any particular method in her classes. She reasoned that there is no generally accepted method that can be deemed the 'scientific method.' She thinks each person uses a specific method of his or her own:

> I don't like the term 'scientific method' because I don't think there is any standard method that all use. In my opinion, there is this general term we call 'methodology' that varies according to its specific users.

When asked about the position of theories and laws in science, Tanya's reply offered another informed opinion:

> Theory is an explanation about how things happen and laws are observations on recurrent events taking place in nature. It is wrong to think that theories become laws when they are

proven; it is not a correct approach to think that they turn into each other and neither can be regarded as absolute.

On the basis of these and similarly informed responses to questions relating to other themes, it can be inferred that in epistemological terms, Tanya held informed ideas.

**Year 2**

**Central Beliefs**

Two themes emerged in the context of pedagogical beliefs that were transitional in the first year, but dropped to one in the second year (Table 4).

**Table 4: Beliefs and classroom practices of Tanya in the second year.**

| Dim. | Themes | Traditional | Transitional | Reformist |
|---|---|---|---|---|
| Methodological | Science Process Skills | | | ◉ |
| | Teachers' Profile | | | ◉ |
| | Teaching Methods | | | ◉ |
| | Evaluation | | | ◉ |
| Conceptual | Learning Approach | | | ◉ |
| Social | Student-Student Interaction | | | ◉ |
| | Shared Control | | ◉ | |
| | Respect to Alternative Ideas | | | ◉ |
| Epistemological | | Naive | Eclectic | Informed |

● pedagogical beliefs
○ classroom practices
◉ nested pedagogical beliefs and classroom practices

The teacher presented transitional ideas on the theme of *shared control* of social dimension and also exhibited transitional practices. In all the other themes, Tanya expressed reformist ideas and engaged in reformist practices accordingly. Thus, all of Tanya's beliefs were determined as central beliefs (*science process skills, teachers' profile, teaching methods, evaluation, learning approach, student-student interaction* and *respect to alternative ideas*).

As stated, the application of the teacher's course during her second year of teaching was relatively successful with the exception of the issue of shared control. When commencing class, the teacher was engaged in good argumentation with students and made them aware of their prior knowledge. She also prepared them for the activity that was to be conducted. After this initial dialog with the students, Tanya gave activity sheets to students and informed them about the experiment and what they were expected to do. The teacher placed 12 different closed box mechanisms in different places of the laboratory. She asked each group to visit these boxes one by one and to guess the shape of the material inside of each box by referring to the materials provided to them. Students were expected to put marbles into the boxes while figuring out the shape of the contents inside of the box in accordance to the angle that it turns to (Figure 1).

She first asked her students to think about how they would use these materials. After receiving satisfactory responses, she told them to commence with the experiment.

Tanya held a transitional-central belief on the theme of shared control, when she asked about how she decides what to teach and what not to, she stated that the traditional view of strictly sticking to the curriculum was wrong. Her words were as follows:

> I must admit sadly that our science community is too rigid on this. They impose as through a curriculum what students must learn. They tell us what to teach, not how to teach. But as I stated earlier I must have been blessed. We are engaged in a good communication and

exchange of ideas on how to teach with three other teachers I am working with. We are working on it if we want to introduce some new things.

Conversely, the teacher also showed that she held another traditional understanding that it should be left to the teachers' initiatives for deciding what to teach and what not to. Her statements fell short of addressing the needs of the students, their level of prior knowledge, or the need to raise a common voice in the decisions to be taken in class.

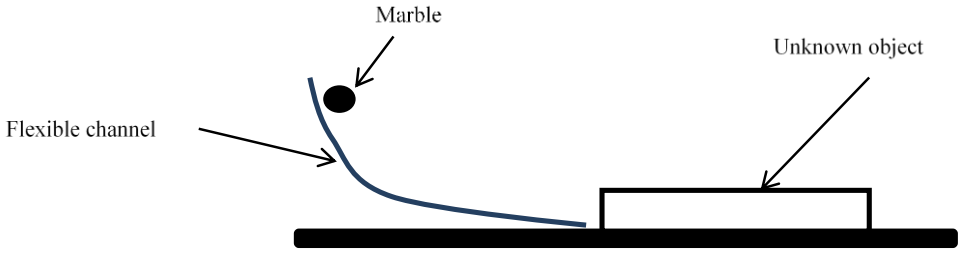


**Figure 1: The mechanism used in second year laboratory implementation**

Examining the theme of shared control with respect to Tanya's classroom practices, it would appear that she was planning them by considering students as part of the learning environment. However, while examining other items on the RTOP scale, we noticed that shared control ranked weaker in relative terms to the other themes on the scale. While designing the course, Tanya determined both the process and scenarios herself and wanted her students to act accordingly. In other words, the students' questions and comments remained weak in terms of the overall contribution to the focal point of the already planned standard course. Participating students were not observed as influencing the direction taken by the course as a whole. Hence, the single transitional idea that remained in the teacher's second year was proven to be a central belief that was also reflected in practice.

**Epistemological Beliefs**

In terms of epistemological beliefs, Tanya also displayed informed approaches in her second year. When asked about her ideas regarding the tentativeness of scientific knowledge, Tanya offered examples explaining that there are changes 'especially in some fields' and it is possible to see them 'even in our own life periods.' She added the following words: 'Let's take the case of the planet Pluto…hmm! Recent information suggests that it is different from a planet and what we used to regard as "correct" may turn to be false in the light of new information.' With this comment, she again presented an informed opinion as was the case in her first year.

Similarly, when asked about the role of theory and law in science, she articulated informed ideas as she did in her first year. While asserting that theories mainly explain the causes of events, Tanya thought that laws, on the contrary, derive from the observation of natural events:

> I think you know it … I introduce theories to my students as structures that explain causes behind something. They are scientific constructions tested many times and cannot be described as an old idea only. Laws are rather observations about the nature. As in the case of Newton's law of gravitation it explains a particle's fall on earth… But nothing is definitive and both may change…

**Year 3**

**Central Beliefs**

In the last year of the study, Tanya was observed to display both reformist beliefs and practices in seven out of the eight themes (Table 5). When asked about how she defined her role as a teacher, she said she regarded herself as a guide:

> I support my students in their learning. I see myself as a guide pointing out to the right direction in their learning of important concepts in science. Each year I am trying to design my courses better, ensure their participation though different ways of teaching based on inquiry and more advanced laboratory techniques.

She backed up these ideas by referring to propositions under the BARSTL scale. She completely disagreed with the proposition that 'An excellent science teacher is someone who is really good at explaining complicated concepts clearly and simply so that everyone understands' (BARSTL item number 22).

**Table 5: Beliefs and classroom practices of Tanya in the third year.**

| Dim. | Themes | Traditional | Transitional | Reformist |
|---|---|---|---|---|
| Methodological | Science Process Skills | | | ◉ |
| | Teachers' Profile | | | ◉ |
| | Teaching Methods | | | ◉ |
| | Evaluation | | | ◉ |
| Conceptual | Learning Approach | | | ◉ |
| Social | Student-Student Interaction | | | ◉ |
| | Shared Control | | ○ | ● |
| | Respect to Alternative Ideas | | | ◉ |
| Epistemological | | Naive | Eclectic | Informed |

● pedagogical beliefs
○ classroom practices
◉ nested pedagogical beliefs and classroom practices

During the interview, Tanya was asked in the context of the theme evaluation, the process in which she decides to go on with the next subject, how she evaluates whether students have really learned a concept, and if learning has actually taken place. She gave a common response to all of the above questions, highlighting the students' ability to apply their knowledge into new situations. Tanya reached this conclusion sometimes by observing her students and sometimes by going over laboratory worksheets:

> 'I often pose my students questions; some implementation-oriented questions. I give and want them to solve real life problems because I don't want them to learn by memorizing (science process skills). I expect them to grasp the topic and adapt it to some new situations (learning approach). Anyway, isn't it science itself?'

In line with these comments, she conducted a laboratory experiment related to electric circuits. To attract the attention of the students when starting the class, she loaded electricity into a balloon by rubbing it with a piece of cloth and highlighted the interaction between the balloon and the pieces of paper. Continuing with electric circuits, she helped the students in their reasoning by associating relevant concepts with practices from daily life (i.e., by referring to electronic home appliances such as switches and lamps). She then drew an electric circuit on the board and tried to impart concepts such as current and resistance by discussing them with the students.

The teacher handed activity worksheets to the students and asked them to work in groups of two. These groups were primarily assigned to draw on their worksheets some electric circuit models so that they could demonstrate different types of electric series and parallel connections. After the

students completed their drawings, Tanya asked them to apply their models and check if they would work by using the cables, lamps, and batteries that she had brought to class. Tanya visited each group several times, examined their models, and tried to encourage discussions on both positive and negative outcomes.

While expressing her beliefs about another theme, student-student interaction, Tanya commented that social interaction was an important element for the exchange of different ideas (student-student interaction). Examining her responses under the BARSTL scale lends support to the idea that the teacher must pose appropriate questions for class discussions to prepare for such an environment. This belief manifested itself during the practice stage of the lesson when students stated their views to the discussion and tried to convince their classmates about their choice of materials. For example, when a bulb placed in a group's circuit did not work, the two members of the group started to discuss the reason behind it.

> Student 1: Is the lamp out?
>
> Student 2: Let's check [the bulb is tested on energy source and found to be working]. I think the problem is with cables.
>
> Student 1: Why? Are they broken off?
>
> Student 2: No, I think it is because of too long cable. Battery falls short and we must use a shorter cable.

**Peripheral Beliefs**

During the third year, Tanya displayed a peripheral belief on the theme of shared control. Tanya also displayed contradictions in that she adopted reformist approaches in practice, but at the same time, held transitional beliefs toward this particular theme. When asked about how she decides what to teach, she answered that as a basis, she takes the district curriculum just as was the case in previous years. However, in cases where the curriculum was not clear enough, she decided together with other teachers what to teach. Tanya's words were as follows:

> There are some silly criteria that we have to observe in these district exams. If the district has no clear decision, we work on this together as teachers and make our decisions as I have pointed out earlier.

As can be seen, there is no consideration of the students' needs and demands in the views expressed by Tanya. This approach, based on the curriculum and teachers' decisions, actually appears to be closer to the traditional approach. In relation to the given BARSTL proposition parallel to this situation, Tanya showed that she was yet to have a clear decision to oppose the proposition that a 'Teachers should allow students to help determine the direction and the focus of a lesson.'

Having a transitional belief, Tanya wanted her students to design different electric circuits in practice according to their own thinking. Hence, students took up an active role in determining the direction of the course. When facing problems, the students tried to come up with different solutions based on their teachers' questions. Evidence of such instances includes one of the dialogs between Tanya and her students:

> Teacher: OK kids, how many different routes are there in this circuit that current can follow?
>
> Student 1 and 2: One.
>
> Teacher: Then think about: There is only one route and while one lamp is out the other is working on the same route. What does it mean to you?

Student 1 and 2: The lamp may not be working.

Teacher: Are you sure?

Student 1: Oh, no! If the lamp were not working the circuit would not be completed and both should not be working in that case.

Teacher: Then what was wrong in your model?

Student 1: Could it be that the battery is too weak?

Teacher: Could be, but why?

Student 1 and 2: …. [No response]

Teacher: Think this way: Each cable and lamp you have in this circuit; what are their functions?

Student 1: Resistance to the current (not so sure)

Teacher: Isn't it? Then what can you do?

Student 1: I think it will work if we remove redundant cables and use two batteries instead of one.

Teacher: So try it and see what happens.

**Epistemological Beliefs**

Just as in her first year, Tanya's epistemological beliefs remained in the informed category in her third and final year. Similar to her first two years, she was adamant that 'theories explain the causes of something' and 'laws are definitions of things we observe in nature.'

When asked about her beliefs concerning scientific methods, she said that she was 'disturbed' by this term and never uses it since there is no method that proceeds in steps. However, the teacher believed in the existence of a logical process through which scientists and other people can participate in the problem-solving activity:

> I do not teach the concept 'scientific method.' Indeed, this term disturbs me a lot. One of our teachers, I heard, is teaching the structure with six steps. I tell my students there are some scientific constructions with their logical processes that people are engaged in solving problems.

In the context of epistemological belief, Tanya consistently displayed an informed stance for all the three years.

## CONCLUSIONS AND DISCUSSION

**Assertion 1: Teachers cannot practice their reformist beliefs without experiencing class environments.**

When we compare the relation between Tanya's beliefs and her practices, there is only consistency in one of the eight themes that were investigated during the first year (12.5%). There was compliance between beliefs and practices in Tanya's approach to learning. Although holding reformist-central beliefs in the theme of learning approach, Tanya was evaluated as holding peripheral beliefs in all the other themes. It was understood that she had reformist-peripheral beliefs in the themes of shared control, teaching methods, science process skills, student–student interaction, and respect to alternative ideas. Tanya was evaluated as having transitional-peripheral beliefs in the themes of evaluation and the role of teachers. The principal reason for this inconsistency is that in her class, Tanya displayed practices more akin to the traditional approach during her first year, with 75% of her beliefs reformist, but with a mere 12.5% engagement in reformist practices.

During the second year, a sharp change was observed in Tanya, and she was evaluated at 100% in the consistency between her practices and beliefs. The reason for this drastic change was changes that she introduced in her classroom practices. Tanya demonstrated reformist-central beliefs in all the themes, with the single exception of shared control where she held transitional-central beliefs. In Tanya's third and final year, despite exhibiting reformist practices in the theme of shared control, her presentation of transitional beliefs led to her evaluation as having transitional-peripheral beliefs in the shared control theme. Having a 87.5% consistency rate, it was observed that Tanya progressed with a reformist direction in terms of her practices starting from her first year, then increasing her belief-practice consistency by an average of 66.6% during the three years (Table 6).

These findings hint that beliefs manifest themselves significantly after practice. In her first year of teaching, although she displayed reformist beliefs, she could not put her beliefs into practice due to her lack of classroom experience. Having gained self-confidence with a second year of teaching, Tanya could reflect on her beliefs and translate them into practice.

**Assertion 2: While the epistemological beliefs of teachers are usually consistent with their pedagogical beliefs and class practices, this consistency is more pronounced in the case of pedagogical beliefs.**

Throughout the three years of observation, Tanya displayed an informed stance in terms of her epistemological beliefs. Some noteworthy outcomes were observed while examining the consistency of these informed epistemological beliefs with her pedagogical beliefs and class practices (Table 6). It was found that there were 24 themes (8 x 3 years) representing pedagogical beliefs that were consistent with a total of 21 themes pertaining to epistemological beliefs for a period of three years (87.5%).

**Table 6: Consistency of pedagogical beliefs, classroom practices and the epistemological beliefs (%)**

| | Pedagogical beliefs-Classroom Practices | Pedagogical beliefs-Epistemological beliefs | Epistemological beliefs-Classroom Practices |
|---|---|---|---|
| 1st year | 12,5 | 75 | 12,5 |
| 2nd year | 100 | 87,5 | 87,5 |
| 3rd year | 87,5 | 100 | 87,5 |
| Total | 66,6 | 87,5 | 62,5 |

One of the findings of this study is that there is a consistency between a teacher's epistemological beliefs and other beliefs that may be called pedagogical (methodological, conceptual, and social). This is supportive of the findings of Tsai (2002). The beliefs that Tsai defined as 'nested' also manifested themselves in this study and qualified the idea that epistemological beliefs play a role in shaping other beliefs or systems of beliefs that mutually feed off each other.

The consistency between epistemological beliefs and class practices was 62.5%. This rate is important and show that teachers' epistemological beliefs constitute an influencing factor in their teaching approach. In other words, epistemological beliefs are quite influential in determining class practices but are not the only factor (Brickhouse, 1990). Teachers' beliefs directly determine their practices; a higher rate of consistency between the two belief dimensions signifies that mentally, teachers are ready for their profession when they start.

With keeping in mind that the study is limited to a science teacher, it can be said, the actual environment experienced by teachers when they first start teaching constrains their ability to turn their beliefs. In particular, some factors inherent in the profession including fear of failure, pre- and post-class preparation, and the need to feel accepted by colleagues and school management contribute to the delay of a teacher's full commitment and engagement in teaching (Haney & McArthur, 2002). As shown by Wallace and Brooks (2015), such problems can be avoided if teachers were to be encouraged before starting their profession to teach in places such as summer camps, which are real but distant from the stressful and formal school environment. Certainly, the absence of such pre-formal experience is an important reason as to why our participant Tanya could not turn her beliefs into classroom practices during her first year, although she was ready otherwise. It can be inferred from the results of this study that getting acquainted with the social and cultural features of her new school and her developing self-confidence (Al Said, Du, Al Khatib, Romanowski, & Barham, 2019; Walkington, 2005), Tanya was soon able to translate her beliefs into class practices and displayed a successful teacher profile by the end of the third year.

The process of change in teachers' beliefs is a long and difficult process (Fullan, 2007) just like changing any kind of beliefs. In Deutschman and Keeler's (2005) book titled 'Change or Die', they say that 91% of people with heart conditions choose to continue their lifestyles that lead them to death rather than changing their way of life and eating. Therefore, it is most likely a futile effort to try to change teachers' beliefs. As seen in the findings of this study, we should change our focus from the "changing of teachers' beliefs" to "helping them to put their beliefs into action". What should be done then is to introduce new approaches and understandings to teacher candidates in teacher training programs and make sure to provide them enough teaching experience (Authors, 2010). Candidate teachers, who have started their career with new approaches, must deal with to put their beliefs into action, not with the change of their beliefs. This will be a more realistic expectation than the expecting teachers to change in both belief and action. Thus, instead of the "change or die" option, we can use the more suitable slogan "put your beliefs into action". We should not wait for the change to take place immediately and continue sowing the seeds for the next generations.

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