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Elementary School Science Teachers' Belief about Science and Science Teaching in Constructivist Landscape

Nasir Mahmood*

Abstract

The study explored the proximity of Japanese science teachers' (both practicing and prospective) beliefs about science and teaching of science in the backdrop of the principles of teaching and learning suggested by constructivism. Furthermore, a comparison of Japanese and Pakistani practicing science teacher's beliefs about science and science teaching was also studied. Five domains were identified in which teacher's beliefs were more likely to affect the classroom practices. A questionnaire, comprising of 28 statements, was made based upon the five domains of beliefs already identified. The data was collected form 314 teachers/prospective teachers, which include 159 Japanese practicing teachers from nine different districts of Japan, 85 prospective science teachers enrolled in teacher training undergraduate course in Tokyo Gakugei University, and 70 Pakistani science teachers from Lahore metropolitan area. From results it was evident that the assumption about different types of science teachers' having different beliefs about science and science teaching was valid. There were differences among different types of teachers and across different domains of beliefs. But overall there was more pro-constructivist tendency among Japanese teachers of all categories as compared to Pakistani science teachers.

Introduction

The research on teacher's beliefs has sufficient evidence to support the notion that teacher beliefs have direct influence on the teacher's practices in classroom. Beliefs influence the manner in which teacher decide his teaching objectives, plan of lesson, approach towards students, and evaluation of learning in the classroom (Richardson, 1996; Pajares, 1992; Munby, 1982; Levitt, 2002; Brickhouse, 1990; Prawat, 1992). The relative share of beliefs among the factors influencing teaching and learning is arguable but its place as one of the main element in determination of classroom dynamics is established. If it is desired to encourage classrooms where constructivist principles of learning are being practiced, it becomes even more important to know about the way in which teachers perceive epistemological underpinnings (Matthews, 1998), theoretical stance (Taylor, 1993) and instructional implication of constructivism.

*IER, University of the Punjab, Lahore, Pakistan.

Constructivism has been interpreted in many different ways (Nasir & Iqbal, 2004) by researchers from various disciplines and background and with the passage of time it has become a very confusing notion. Thus, it has become hard to describe what it may look like when "constructivist principles" applied in science classroom. Therefore, it is felt necessary to describe what is meant by constructivist principles for this particular research study. Following constructivist principles were in the background while writing questions/items in the questionnaire for the exploring beliefs of science teachers across all five domains.

1. providing greater opportunity to students to talk their mind,
2. valuing student opinion,
3. helping students making sense of class talk,
4. developing consensus among class fellows on the learned, and
5. appreciating new scientific ways of describing phenomena.

This research is meant to explore the beliefs of Japanese practicing/ prospective elementary school science teachers about nature of scientific knowledge and science teaching by inquiring, how a challenging innovation like constructivist instruction will likely be dealt by the teachers through looking into their beliefs as suggested by Munby (1984). To conclude about the relative state of constructivist-compatibility of Japanese Practicing/ prospective science teachers, their results will be compared to Pakistani practicing science teachers. The supposition is that Japanese teacher practices some of the constructivist principles in their lessons without being necessarily aware of constructivist principles.

Before getting into the review of the current status of research on science teacher's beliefs it seems appropriate to define the term *beliefs* as used in this research to avoid any confusion as the term is traditionally used for variety of constructs by different researchers (Pajares, 1992). In the context of this research it is assumed that beliefs are inferred from a situation being experienced by an individual. It is also assumed that beliefs are context dependent (Cooney, Shealey & Arvold, 1998) and held in different intensities.

Developments in Research on Teacher's Belief

These tacit, unconsciously held, but deep-rooted beliefs need a purposely-designed questionnaire, an interview, or careful and patient observation to bring forth. But once explored successfully, they can prove to be very precious psychological constructs, as put by Pintrich (1990), for the improvement of teaching and learning.

Kagan (1992) has summarized more than twenty-five qualitative and quantitative research studies carried out in last two decades for exploring practicing and prospective teachers' beliefs in varied regards like sense of self-efficacy, convictions about teaching methodology, teacher's role in the classroom, student behaviors, classroom discipline, and process of learning. Direct proportionality of self-efficacy to student achievement, nature of instruction to student participation, and teacher's orientation of teaching to types of classroom practices was reported in these studies (pp. 68-71). One domain not included in the Kagan's (1992) analysis was the studies on relationship of teacher's epistemological beliefs about science as a body of knowledge and implications for school teaching. The studies explicitly addressing this rather philosophical issue are very few (Tsai, 2002) but researchers have showed that epistemological beliefs play a key role in the way they interpret scientific knowledge and in turn teach it in classroom (Pajares, 1992; Gallagher, 1991; Hashweh, 1996).

Moreover, there is a lot to be desired when it comes to investigating adjacency of science teacher's beliefs with the constructivist principles. In the rare studies available, Hashweh (1996) has revealed that constructivist teachers are better prepared to use more effective strategies for inducing conceptual change but Tsai (2002) found that majority of the science teachers still lack the proper conceptual framework needed for addressing the issues of science and science teaching. Encouragingly, this lack of conceptual framework is amendable with proper exploration of beliefs held by the science teachers and suitable training as reported by Peterman (1993) through a case study reported following change in a teacher's beliefs during a training course. Building upon the limited researches available, it can be said that exploring the teacher's beliefs compatibility with constructivist principles will be a good indicator of type of classroom practices more likely to occur in the schools where such teachers teach.

Purpose and Research Questions

This study is done to explore the proximity of the teacher's beliefs (both practicing and prospective science teachers and Pakistani elementary school science teachers) to the constructivist principles of learning for

1) Finding the Japanese practicing/prospective elementary school science teachers' beliefs about science and science teaching against the constructivist principles as the supposition is that pro-constructivist beliefs in teachers will ensure the establishment of constructivist practices in classroom instruction
2) Exploring the comparative position of Japanese and Pakistani teachers for proximity of classroom practices to pro-constructivist principles. This will inform about the relative positioning of Japanese classrooms in terms of the constructivist practices.

Method

In conformity with the objectives of the research, five domains were identified in which teacher's beliefs were more likely to affect the classroom practices. Ideas were collected from the constructivist literature to formulate the question statements, which can address the compatibility of science teacher's beliefs to the constructivist principles in each of the five domains.

Data source

A questionnaire was made based upon the questions prepared in each of the domains above to collect the data. The questionnaire initially comprised of 32 question but only 28 statements were used finally for the purpose of analysis. The four questions excluded were alternative questions included as reworded version of already present conceptual construct to offer the respondents alternative statements to ensure the quality of the data collected. The distribution of the remaining statements was as; 4 statements related to each domain except teaching and learning science, which had 12 items. The respondents were to select one of the options on a 5-point scale between 1 (completely disagree) and 5 (completely agree).

Description of the belief domains

Table 1 briefly describes the content of the questionnaire by elaborating each of the belief domains through explaining the constructs forms included in the respective domains. *First domain* is "Nature of scientific knowledge" and it is meant to address the teachers' beliefs about science as a body of knowledge and the process of development of scientific knowledge and, cultural and social relevance of science. *Second domain* includes questions regarding the perception of likely changes due to the advancements and increased access of both teachers and students to the technological tools in and outside the classroom, particularly due to increased use of voluminous resources on World Wide Web (WWW).*Third domain* is addressing one of the main (in some respects unique) premises of constructivist instruction, which is the depth of students' participation. The questions are addressing the students' participation in decision making of what and how of learning activity and other classroom matters. *Fourth domain* is to inquire teacher's perception of the meaning associated to learning; its dynamics, and subsequently what teacher can do to make learning happen. The perceptions teacher holds about the act of learning undoubtedly is reflected in the approach he /she takes in teaching. Therefore, most of the question address the meaning attached to learning process in terms of the approach adopted by the teacher to make learning happen. *Finally*, teachers are asked about the concept of effective and useful evaluation. Their views are explored to find out the place they assign to students in the process of evaluation (i.e. as a partner in evaluation). Issues like who, when, through what means, and for what, assessment should be carried out were also included

Table 1
Description of the constructs inquired in five domains of science teacher's beliefs

Belief domain	Constructs inquired	Example
Nature of scientific knowledge (4)*	- Process of generation of scientific knowledge, - Nature of science as a body of knowledge, - Social and cultural context of science, and - Responsibility of developing scientific knowledge	Science being knowledge of rules, logic and verifiable facts is independent of social and cultural boundaries. (negative statement)
Effects of technology on teacher (4) *	-Relationship of technology (like introduction of teaching software, internet etc.) to the capacity of teacher - Effect on the role of teacher - Challenges form more aware students (in terms of the access to other resources compared to textbook only in the past)	Advancements in students access to information tools like world wide web (www) and electronic information has made teacher irrelevant. (negative statement)
Student participation in lesson (4)*	- Students' role in decision making of the objectives of learning. - Student-centered approach in teaching - Listening and valuing students' experiences. - Participation of Student in evaluation of learned by getting their self-evaluation.	Student participation in lesson means to share their ideas when deciding the objectives of the lesson.
Teaching and learning science (12)*	- Intent of teaching and learning -Teacher's role in the classroom -Place of previous knowledge and experience of students in teaching and learning. -Selection of methodology • Contribution of classroom environment of teaching and learning. • Structuring of learning around concepts • Relationship of science to other subjects.	Over simplification of scientific concepts while teaching is similar to giving incomplete knowledge.
Nature of student evaluation (4)*	- Purpose of assessment - Modes of assessment - Timings of assessment	Assessment can be used as a source for improvement in learning if made a continuous activity.

*Number of statements in the questionnaire

Participants

All the participants were elementary school science teachers, either practicing or prospective. In sum, the data was collected form 314 teachers/prospective teachers, which include 159 [35 science teacher who graduated with science as major subject (will be called 'science teacher') while 124 are those who majored in subject other than science (will be referred as 'class teacher')]Japanese practicing teachers from nine different districts of Japan, 85 students (will be referred as prospective science teachers) studying in teacher training undergraduate course in Tokyo Gakugei University, and 70 Pakistani science teachers from Lahore metropolitan area.

Data analysis

The collected data was grouped into five domains for all four categories of the science teachers as described in the methodology section. The data analysis was as follows:

1. A one–way analysis of variance was conducted to investigate the difference between teacher types (Japanese practicing science teachers, Japanese practicing class teachers, Japanese prospective science teachers, and Pakistani science teachers) on each of the five domains of teacher's beliefs.
2. Pattern of item (question) means ($\bar{x}$) within each domain was explored to further clarify the areas on which, different types of teacher have varied opinion.
3. 'Difference size' was calculated between teacher types on each of the five domains of teacher beliefs for closer understanding of the exact domain(s) on which a particular teacher type differs from the other.

Results

When subjected to one-way ANOVA, significant difference was found for the between subject analysis on each of the five belief domains and total score. Teacher Types was treated as fixed factor while belief domains were taken as dependent variables. The results of the F-test and degree of significance are shown in Table 2 It is evident that the assumption about different types of science teachers' having different beliefs about science and science teaching was valid.

One-way ANOVA only ensured the presence of significant difference between various teacher types on belief domains but to locate the bi-group difference between all possible combinations of groups Tukey test was applied. It was found that there is no significant difference between the beliefs of Japanese practicing science teachers (G1) and class teachers (G2). Also, Japanese prospective science teachers (G3) hold almost same beliefs

Table 2

Results of One-way ANOVA & Between-Group Difference Analysis by using TUKEY HSD test for Four Groups of Practicing/Prospective Science Teachers on Five Domains of Teacher Beliefs

	Group1 N= 35	Group2 N=124	Group3 N= 85	Group 4 N=70	Total N=314	F	Between- group difference (Tukey HSD) ✓: significant difference **G:** Group					
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)		A G1-G2	B G1-G3	C G1-G4	D G2-G3	E G2-G4	F G3-G4
a) Nature of scientific knowledge (4)	16.6 (2.6)	15.8 (2.3)	16.2 (2.5)	9.0 (3.2)	14.5 (3.9)	136.3*			✓* >		✓* >	✓* >
b) Effects of technology on teacher (4)	11.9 (1.0)	12.0 (1.2)	12.2 (1.6)	14.2 (3.0)	12.5 (2.1)	25.4*			✓* <		✓* <	✓* <
c) Student participation in lesson (4)	15.6 (2.6)	15.8 (1.8)	14.6 (2.0)	13.1 (2.8)	14.8 (2.4)	23.2*			✓* >	✓* >	✓* >	✓* >
d) Teaching & learning of science (12)	40.1 (3.6)	39.9 (4.0)	39.6 (3.8)	33.5 (4.0)	38.4 (4.7)	48.0*			✓* >		✓* >	✓* >
e) Nature of student evaluation (4)	16.3 (1.8)	16.1 (2.2)	15.2 (1.7)	12.3 (2.3)	15.1 (2.6)	53.1*		✓*** >	✓* >	✓** >	✓* >	✓* >
Total score (28)	100.5 (6.8)	99.5 (7.6)	97.7 (7.2)	82.2 (7.3)	95.3 (10.2)	97.2*						

*p< .001 **p< .01 ***p< .05 () Number of questions.

Group 1: Practicing Science teachers (Major sc.) **Group 2:** Practicing Science teachers (Others) **Group 3:** Prospective Science Teachers
Group 4: Practicing Pakistani Science Teachers

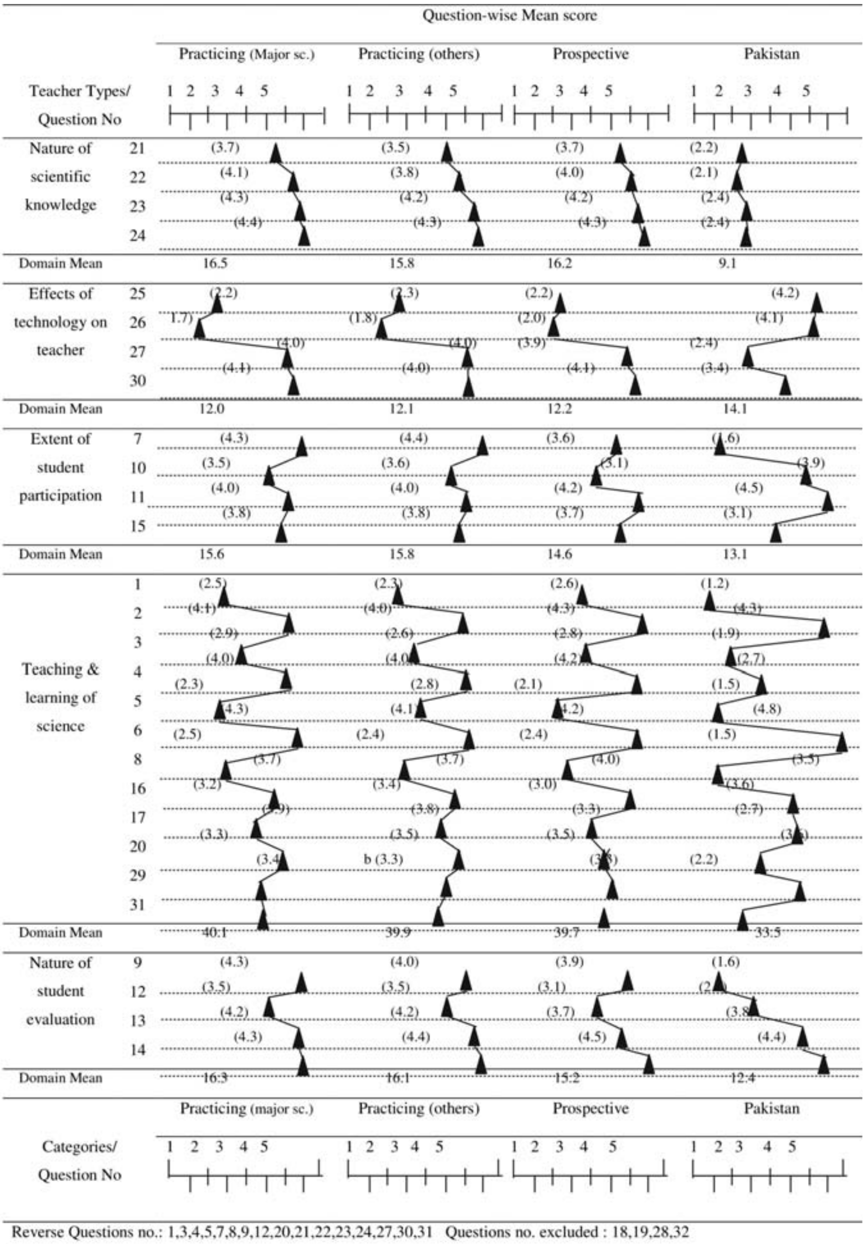

Figure 1: Comparison of Means pattern among Japanese practicing and prospective science teachers and Pakistani practicing science teachers on five beliefs domains

as teachers in G1 and G2 except about the nature of evaluation. In addition, Japanese prospective science teachers (G3) differ from Japanese practicing science teachers (G1) regarding the students' participation in the lesson too.

All three groups of Japanese teachers have significant difference on all domains of beliefs compared to their counterparts in teaching science in Pakistani elementary schools (G4).

Another noticeable result is the similarity of the pattern in the beliefs of Japanese practicing/prospective science teachers, which is shown in Figure 1. Although some difference in mean (x) is found if looked upon question by question, which indicates a degree of correspondence in the beliefs of the respective groups.

On the other hand, a clear difference between Japanese practicing/ prospective science teachers (G1, G2, and G3) and Pakistani practicing science teachers (G4) in favor Japanese groups of teachers indicate more congruity of Japanese teachers to the constructivist principles on total score.

But when it comes to each of the five domains, both practicing and prospective Japanese science teachers showed pro-constructivist beliefs about nature of scientific knowledge in comparison to Pakistani counterparts.

It is reversed, when it comes to effects of technology on teaching practices. Pakistani practicing teacher (G4) believe that technological advancements and access to web resources have facilitated their job, and changed their role but Japanese practicing/prospective teacher (G1, G2 and G3) does not see IT advancements causing any considerable change in their role.

Japanese practicing science teachers (G1) are more convinced about the increased students' participation in the classroom activities as compared to both Japanese prospective science teachers (G3) and Pakistani practicing science teachers (G4). Pakistani practicing science teacher's lower support for student involvement is because of the traditional trend of using lecturing as most popular teaching methodologies (Nasir & Shinohara, 2002)

All four types of teachers have pro-constructivist beliefs when it comes to practice of teaching and learning of science. This shows a clear indication of more probability of constructivist compatible instruction in Japanese science classes.

Japanese practicing/prospective science teachers' (G1, G2 and G3) approach toward students' evaluation is more constructivist-compatible than Pakistani counterparts. Even some difference between Japanese practicing teachers (G1 and G2) and prospective teachers (G3) in favor of G1&G2 is observed.

Higher d-scores shown in Table 3, between Pakistani practicing science teachers (G4) and rest of the three (i.e. G1, G2, and G3) groups of teachers reflect the extent of difference in the Pakistani and Japanese (all three types) teachers' belief regarding the five domains under investigation. The difference is least in the beliefs about teaching and learning science but wider when comes to nature of scientific knowledge, effects of technology on teacher, students' participation in lesson and nature of evaluation.

Table 3
Inter-group d-score between Teacher Types on Five belief domains

Science Teachers Type	Belief Domains																			
	Nature of scientific knowledge (4)				Effects of technology on teacher (4)				Student participation (4)				Teaching & learning of science (12)				Nature of student evaluation (4)			
	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4	G1	G2	G3	G4
Group 1 (G1)		.04	.01	3.47		.01	.03	3.2		.01	.17	2.05		.04	.06	.79		.03	.15	2.07
Group 2 (G2)			.02	2.86			.02	2.96			.24	2.17			.10	.75			.11	1.68
Group 3 (G3)				3.18				2.97				1.27				.73				1.39
Group 4 (G4)															.					

G1: Japanese Practicing Science Teacher G2: Japanese Practicing Class Teachers

Discussion

Implication of the results can be followed on two different lines; standings of each of the teacher type for constructivist-compatibility of beliefs and comparison of the teachers' beliefs on five inquired domains among the four types of teachers

Nature of scientific knowledge

Majority of Japanese teachers (G1, G2, and G3) does not perceive scientific knowledge as revealed truth but liable to error thus students' should not to be taught to blindly believe it. Moreover, they view scientific knowledge as embedded in the social and cultural context of society, thus for recognizing it's relevance to daily life being important element of science teaching. This consequently strengthens the assumption that elementary school science education in Japan is quite compatible to constructivist principles in its existing form. These findings are very encouraging and radical in nature, as traditionally it is believed that science teachers mostly see science as body of fixed and unchallengeable facts. This traditional description holds well for Pakistani teachers, who on contrary align more with the science as a body of fixed, culture free and undeniable discipline of knowledge.

This research does not provide any evidence to attribute this unorthodox revelation about Japanese teachers' belief any particular element except that it is by virtue of quite flexible and socially integrated elementary school education setup. This needs further study by extending the exploration of scientific beliefs of junior high school and high school science teachers, which is known for it's more structured and traditional framework.

By comparison, all three (G1, G2, and G3) types of Japanese science teachers hold similar beliefs that this approach toward the nature of scientific knowledge may have been a result of teacher training imparted on the lines to view science as a socially relevant progressive body of knowledge.

Effects of technology on teacher's role

This is the only domain in which Japanese science teacher's belief; particularly practicing teachers' beliefs are less constructivist-compatible than Pakistani science teachers. Japanese practicing teachers (G1 and G2) does not perceive developments in IT as a source of change in their role in the classroom instead they think that it has minimized their role. This difference in perception is due to the difference of "theory and practice". Pakistani practicing science teachers (G4) and Japanese prospective science teachers (G3) scored higher as none of them has yet used the IT in actual practice and their beliefs are based on perception rather than practice, while Japanese practicing teachers (G1 and G2) are actually passing through this experience (although at very early stage of experiencing that shift) and this shift is seemingly hard for them adapt.

Student participation in lesson

Getting students involved in sharing decision making of lesson objectives, activities, and assessment needs experience, skills and self-confidence in addition to favorable administrative and social support. Japanese practicing teachers (G1 and G2) have shown more positive approach in this domain compared to Japanese prospective science teachers (G3). All three types of Japanese teachers' beliefs are in favor of more students' participation than Pakistani science teachers (G4), which reflects difference in the frame of mind between Japanese and Pakistani teachers and their respective beliefs about the nature of scientific knowledge.

Teaching and learning of science

In general, all four types of teachers have pro-constructivist beliefs when comes to teaching and learning of science but Japanese teacher (both practicing and prospective) particularly are more in conformity with constructivist approach as compared to Pakistani teachers.

Science teaching is seen as best learned through hands-on activities, and students' involvement in deciding the method of learning are surely indicators of constructivist-compatible beliefs. Despite this compatibility in most of the beliefs the idea of teacher being responsible for making student memorize the knowledge given in textbook is not quite in coherence with constructivist principles because still in most of the schools the efficiency of teacher is gauged by the stuffing more and more information in students and performance is assessed by grades on term tests rarely asking for any application of learned but simple facts. Correspondingly, teachers still lay more emphasis on transfer of knowledge. The amenability in the beliefs can only be achieved by harmonizing every sphere of school and community practices towards more practical and usable science education by introducing constructivist approach in overall thinking.

Nature of student evaluation

Once again, Japanese teachers (G1, G2 and G3) differ positively from Pakistani science teachers in terms of purposes, modes and timings of student evaluation. The system of no formal examination for the promotion to next grades in elementary schools of Japan has probably contributed to more comprehensive evaluative approaches among Japanese teachers. In contrast to Pakistani teachers, Japanese teachers perceive evaluation as more than just assigning grades to students by making it a continuous activity; a part of lesson by observing students working, having interactive dialogue with them, and reviewing their daily notes.

In view of the pro-constructivist nature of beliefs of Japanese teachers, it is very likely that Japanese elementary school students are being exposed to constructivist learning in many respects and a conscious effort in this regard will not be that hard to implement. The inference need further qualification because exploring beliefs can be very deceptive at times if not carried about by following the initial responses of the teachers. A questionnaire is a good source for gathering information from wider sample but has its limitation that follow up investigation cannot be carried out.

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