Science & Education
https://doi.org/10.1007/s11191-024-00563-7

ARTICLE

# Bhutanese Primary Science Teachers' Epistemic Beliefs of Science

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Accepted: 19 September 2024


**Abstract**
Epistemic beliefs of science (EBS) are considered to have a strong influence on how science teachers view science itself and carry out science teaching. To this end, Bhutanese primary science teachers, as much as secondary science teachers, are expected to possess sophisticated EBS. While this is one of the aims of the Bhutanese science education system, there is little to no information regarding Bhutanese primary science teachers' EBS. Hence, this cross-sectional study examined EBS held by primary science teachers from three districts in Bhutan. One hundred and ninety-five ($N=195$) primary science teachers took part in the study using a total population sampling design. Data collected using the Epistemic Beliefs of Science Questionnaire (EBSQ) were analysed using descriptive and inferential statistical methods. Findings revealed that Bhutanese primary science teachers from three districts in Bhutan held naive EBS in several aspects of source, certainty, development, and justification dimensions of scientific knowledge. The chi-square test of independence ($\chi 2$) revealed that there were no significant relationships between Bhutanese primary science teachers' EBS and their teaching background ($p > .05$). The one-way analysis of variance (one-way ANOVA), while showed significant differences in certainty dimension, revealed that were no significant differences among Bhutanese primary science teachers' EBS in other dimensions based on their academic qualifications ($p > .05$). The implications of research findings to the Ministry of Education, science curriculum documents, and teacher preparation are discussed.

## 1 Introduction

Science has become a significant part of human culture (National Research Council [NRC], 2012). It has set into almost every department of our life ranging from small matters, such as making tea to awe-inspiring like deep space exploration. Science has, therefore, changed the course of human history and the nature of human lives, and it continues to do so even today (Dorji et al., 2022; Khishfe, 2012). Thus, individuals must understand

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Published online: 01 October 2024

science, including the nature of scientific knowledge and how it is developed (Deng et al., 2014; Jatsho & Dorji, 2022). These aspects of science, which are collectively referred to as epistemic beliefs of science (EBS), are critical as individuals are required to make informed decisions, assess policy matters, and be critical consumers of science (Allchin et al., 2014; Kartal et al., 2018; Lederman et al., 2014).

Conceptually, EBS is conceived as an individual's beliefs about the nature of knowledge and the nature of knowing (Hofer & Pintrich, 1997). At the heart, there is a widespread agreement among science education scholars that EBS play a crucial role in science education (Lammassaari et al., 2021; Ongowo, 2022; Tsai et al., 2011; Wu et al., 2020). This is because EBS, for many reasons, is inherently conceived to remain closely intertwined with science learning (Elby et al., 2016; Sengul et al., 2020). The EBS, for instance, are largely known to shape and influence science teachers' beliefs of science and teaching of science (Fives & Buehl, 2016; Kampa, et al., 2016), and the way students see science and conceptions of learning science (Ho & Liang, 2015; Lee et al., 2016; Liang & Tsai, 2010).

As science teachers' EBS are known to determine science learning, science teachers must maintain sophisticated EBS by the shared views of scientific communities (Deng et al., 2014). Typically, science teachers with sophisticated EBS are deemed to situate their classroom teaching based on constructivist approaches to learning. On the contrary, science teachers who come with little to no sophisticated EBS would traditionally choose to optimise lessons based on conventional approaches (Fives & Buehl, 2016; Kampa, et al., 2016). As such, science teachers cannot possibly teach and help their students with what they do not understand (Abd-El-Khalick & Lederman, 2000; Capps et al., 2012). Science teachers' EBS, especially the shared epistemic views maintained by scientific communities, are, thus, prerequisite conditions necessary for effective science teaching.

## 2 Theoretical Framework

### 2.1 Epistemic Beliefs of Science (EBS)

Typically, EBS has its roots, originating from the domain-generic epistemic beliefs (EB) proposed by Hofer and Pintrich (1997). As it is evidenced in science education literature, there are several ideas (models) pioneered to explain what lies beneath EBS. A model proposed by Conley and colleagues (2004) is one common approach (Conley et al., 2004; Schiefer et al., 2021), and it contains four epistemic dimensions. These include the *source of scientific knowledge*, *certainty of scientific knowledge*, *development of scientific knowledge*, and *justification of scientific knowledge*.

Typically, each dimension of the EBS model proposed by Conley et al. (2004) has its share of meaning. The *source* dimension, for instance, attempts to address beliefs about the knowledge that resides in external authorities. Simply put, it demonstrates a range of notions from having strong beliefs in authorities, such as teachers and books, towards becoming aware of critical evaluation, scrutinising authorities, and the ability to produce knowledge through one's imagination and thinking. The c*ertainty* dimension, on the other hand, reflects the beliefs ranging from the existence of an absolute or the supreme answer to the prevalence of a multitude of answers in science. The *development* dimension is connected with the beliefs that acknowledge science as an evolving and changing discipline. In other words, it posits that scientific knowledge does not develop to become a discipline whereby scientific answers are continuously developed (e.g., based on new evidence).

Finally, the *justification* dimension refers to the role of experiments and other scientific warrants involved in evaluating the objectivity of the scientific claims. It ranges from the beliefs that consider data and experiments as the main basis to support arguments to the acceptance that knowledge is explained and justified in many ways, using thinking tools, logical and mathematical analyses, experimentations, and observations (Conley et al., 2004; Schiefer et al., 2022).

## 2.2 Science Teachers and EBS

Given that EBS is inherently known to shape and influence science teachers' beliefs of science, conceptions of science teaching, and classroom teaching, they must maintain advanced EBS. As posited by Schiefer et al. (2022), for this study, the latter ends of the described continua for each EBS dimension (scientific knowledge can be revised; scientific answers can constantly evolve; it is essential to reflect on sources of knowledge; and knowledge can be justified in various ways, including observation, experiment, and logical analyses), represent matured and sophisticated stances of EBS. According to Conley and colleagues (as cited in Dorsah et al., 2020; Schiefer et al., 2021, 2022), any individuals who are said to possess sophisticated EBS must not strongly believe in external authorities (e.g., scientists, teachers, and books); understand that science can have more than one answer; view scientific knowledge as evolving and changing; and value evidence, observations, experimentations as the primary ways of justifying scientific knowledge. On the contrary, any science teachers who are said to possess less sophisticated EBS would, oftentimes, try to rely strictly on external authorities; assume science as static and accumulation of facts; consider science as a discipline that values one concrete answer; and use authority and experiments to justify scientific knowledge (Hofer, 2000; Rosman et al., 2017).

Virtually, research on EB has centred only on the domain-general EB, school-going children's EB, or pre-service science teachers' EBS. As such, not much has been explored about in-service science teachers' EBS. However, in a recent study conducted by Sengul (2024) and Sengul et al. (2020), science teachers from Turkish public high schools expressed authoritarian views of science. These teachers, for example, ascribed to the view that while science can be learnt from using daily experiences and observations, it is highly essential to maintain strict adherence to science textbooks, science teachers, private tutors, and Internet sources to score high marks. In a similar vein, an overwhelming majority of senior secondary science teachers from Taiwan (e.g., Lee et al., 2016; Tsai, 2002, 2007) and Singapore (e.g., Caleon et al., 2018; Chai et al., 2006, 2010) expressed a notion that implied science textbooks and science teachers as the supreme source of scientific knowledge.

The tentativeness of scientific knowledge has been perceived differently. For example, Turkish science teachers ascribed to the temporary notion of scientific knowledge (e.g., Aslan & Tasar, 2013; Dogan & Abd-El-Khalick, 2008) and Portugal (e.g., Torres & Vasconcelos, 2015), whereas Thai (e.g., Sangsa-ard & Thathong, 2014) and Chinese (e.g., Ma, 2009) counterparts believed in the static nature of scientific knowledge. According to Jain et al. (2018), science teachers who subscribe to scientific knowledge as reliable and durable regard science as absolute and certain. Sadly, while being aware of the temporary nature of science, some science teachers simultaneously believe that science becomes stronger with the accumulation of evidence (e.g., Apostolou & Koulaidis, 2010; Dogan & Abd-El-Khalick, 2008). In practice, science can never attain the proven status irrespective of the mounting amount of evidence (Lederman et al., 2002).

Although there is no definite answer in science, science teachers often tend to think about the prevalence of one correct answer. In a recent study by Sengul (2024), physics teachers from Turkey implied that science textbooks, irrespective of discipline, should contain absolute truths and accumulated facts. Apart from this, these physics teachers felt that scientific theories and laws should occupy science textbooks as universal knowledge for everyone to memorise. Consistently, similar observations were recorded in the earlier studies conducted in Turkey (e.g., Bendixen & Corkhill, 2011; Sengul et al., 2020).

Although there is no such thing as a scientific method, science teachers often conceive science as a fixed step-by-step process. Science teachers who tend to think as a recipe-like process assume scientists as strictly adhering to the same procedures of scientific experiments, while there are other ways of doing science, such as observation, description, and classification of organisms, events, and situations to understand phenomena and derive patterns (Eliyahu et al., 2020; Lederman et al., 2014; NRC, 2012). The notion that considers scientific experiments as the sole source of scientific knowledge was habitually expressed by science teachers in Portugal (Torres & Vasconcelos, 2020), Turkey (Mihladiz and Dogan, 2014), and Thailand (Buaraphan, 2013).

### 2.3 EBS and Science Teachers' Demographic Variables

Literature in science education indicates that EBS, including the notions of the nature of science (NOS), is interconnected with demographic variables (Deniz et al., 2008; Pintrich, 2003). Largely, individual factors, such as gender, age, educational qualifications, socioeconomic status, and alike, as per Hofer and Pintrich (1997) and Schommer (1998), facilitate either sophisticating or constraining the EBS. Although numerous empirical studies imply the close associations between EBS and individual factors, most studies have, however, centred on students' EBS in terms of gender (e.g., Chen, 2012; Conley et al., 2004), age (e.g., Conley et al., 2004), grade (e.g., Chen, 2012; Schiefer et al., 2021), and socioeconomic status (Kampa et al., 2016; Ozkal et al., 2010). Further, while recent studies have been carried out to examine science teachers' EBS concerning their beliefs in teaching and learning science (e.g., Belo et al., 2014; Mansour, 2013), there is little to no information concerning science teachers' EBS concerning their teaching background and educational qualifications. As such, it looks genuine to examine how their teaching background and educational qualifications moderate science teachers' EBS.

### 2.4 EBS in Bhutanese Context

Science education in Bhutan depends heavily on the principles of Western science education. As elsewhere around the world, it is not surprising that Bhutanese science teachers are nationally required to possess a sophisticated understanding of science and the salient features of science itself (Jatsho & Dorji, 2022; Ministry of Education [MoE], 2022). For instance, the Bhutanese science curriculum framework mandates that Bhutanese science teachers have in-depth and accurate views of EBS. These include some of the main goals including the nature of science (NOS), how science works, how scientists work, and the way scientific knowledge is generated and validated. In this regard, there are widespread expectations that Bhutanese science teachers, just like anywhere around the world, create the necessary conditions that allow students to develop rich, accurate, and sophisticated views of EBS (MoE, 2022). While this aspiration looks to be certainly noteworthy, the ability to realise such a level of national significance would critically remain in the hands of Bhutanese science teachers themselves.

Not surprisingly, EBS always remained an area rarely studied by academics in Bhutan. Hence, there is no literature concerning Bhutanese science teachers' EBS. Although reports on Bhutanese science teachers' cognitive understanding of the NOS have made some headways (e.g., Dorji et al., 2022; Jatsho & Dorji, 2022; Wangdi et al., 2019), the NOS being a different concept does not reflect EBS. Moreover, while EBS is a well-researched topic in the international context, findings from previous studies around the world may not necessarily reflect or, at least not fully, represent Bhutanese science teachers' EBS. The reason for this is that Bhutanese science teachers experience somewhat different contextual backgrounds, including education systems, school systems, curriculum, assessment, pedagogy, and societal and cultural settings. Theoretically, epistemic beliefs, including any belief systems, are recognised to be mentally shaped by and tend to be socially and culturally specific (Lammassaari et al., 2021; Yang et al., 2020. Winberg et al., 2019). Because of this gap, conducting research and establishing the status of EBS perceived by science teachers in Bhutan looks genuine.

Meanwhile, science in the primary grades is largely taught by science teachers who lack either many specialisations or do not possess a teaching background in science itself (Tshomo, 2024). What is more, unlike secondary science, science in primary grades from grades four to six is also taught by science teachers who are generally perceived to possess low academic qualifications and less teaching experience (Mongar, 2022; Wangdi & Utha, 2020). Considering these scenarios, science teaching in primary schools in Bhutan became one of the major highlights in recent years (Tshomo, 2024). However, given that there is a paucity of research, there is little to no information, including the status of EBS perceived by science teachers teaching across primary schools in Bhutan. Therefore, to address this educational gap, this study examined Bhutanese primary science teachers' EBS. Furthermore, to generate a matter of social significance, Bhutanese primary science teachers' EBS were compared based on their teaching backgrounds and educational qualifications. Therefore, the study was guided by the following research questions:

1. What are Bhutanese primary science teachers' epistemic beliefs of science?
2. Are Bhutanese primary science teachers' epistemic beliefs of science related to their teaching backgrounds and educational qualifications?

## 3 Methods

### 3.1 Study Design

This is a cross-sectional study that examined the EBS held by Bhutanese primary science teachers from three districts in Bhutan. The study was, indeed, a non-experimental and quantitative research founded upon the positivist paradigm. As being quantitative in design, the study collected numeric data and analysed using statistical methods. The statistical findings were employed to explain science teachers' EBS, test specific assumptions related to science teachers' EBS, and infer about the EBS held by science teachers from three districts in Bhutan.

### 3.2 Samples

This study was carried out at the beginning of 2024 when the Ministry of Education organised two-day training for all the primary science teachers from *Tashigang*, *Zhemgang*, and *Wangduephodrang* districts. As such, the study sample consisted of 195 (male, $n=120$) primary science teachers. They were recruited using a total population sampling strategy because almost all the primary science teachers from these three districts in Bhutan were found taking part in the training.

The maximum number of science teachers ($n=91$) came from the *Trashigang* district, followed by 62 teachers from *Wangduephodrang* district. As obvious, there were only 42 science teachers from the *Zhemgang* district. Although the majority ($n=165$) of them were from a general teaching background, there were 30 of them who possessed a science teaching background (physics, chemistry, or biology). A bulk majority ($n=154$) of them had a bachelor of education (B.Ed.), whereas 25 teachers possessed a primary teaching certificate (PTC) as their recent educational qualification. The rest of the teachers possessed either master's or postgraduate degrees in education (PGDE).

### 3.3 Data Collection

Data were gathered using an Epistemic Beliefs of Science Questionnaire (EBSQ). The EBSQ, while it contained Likert-type items adopted and/or adapted from the instrument developed by Conley et al. (2004), contained Likert-type items developed by the researchers. The EBSQ was designed on Google Forms and was administered to the teacher participants using a Telegram group chat. The study observed research ethics by seeking informed consent from each participating teacher and obtaining administrative approval from MoE before the survey. The participants were also informed as to how their identities would remain confidential throughout the study report.

The EBSQ measured Bhutanese primary science teachers' EBS along four dimensions, and these include s*ource*, *certainty*, *development*, and *justification* of scientific knowledge. The *source* dimension measured respondents' idea of scientific knowledge residing in external authorities, while the *certainty* dimension was concerned with respondents' beliefs in science as having one correct answer. The *development* dimension, as it implies, measured the beliefs that regard science as a changing discipline, while the *justification* dimension was purported to examine respondents' notion about the justification of scientific knowledge using various scientific investigations (Conley et al., 2004).

The EBSQ contained 21 close-ended Likert-type items. The *source* dimension contained 6 items, while the *certainty* dimension was measured using 5 items. Similarly, the *development* dimension was measured on 4 items, whereas the *justification* dimension was examined using 6 items.

The teacher participants responded to the EBSQ items by choosing one of the levels of response categories namely "agree", "neutral", or "disagree". The scale of the EBSQ is different from the earlier instrument developed by Conley et al. (2004) which contained five response categories. As it happens to be, there is no real reason suggested by the researchers in the literature that favours one format of response options over another. Hence, it is no surprise that scales that include three response categories are found to be as common as the other alternative scales, such as five or seven response categories (e.g., Felix, 2011;

Mellor & Moore, 2013; Polit & Beck, 2006). The use of three response categories for this current study, however, was mainly motivated to provide greater differences among the response categories which is often complex and confusing in the instruments that make use of numerous response categories (Abulela & Khalaf, 2024; Willits et al., 2016).

The EBSQ was different from the earlier instruments developed by Conley et al. (2004), especially in terms of the number of items, the structure of items, and the number of response options. Given these differences, the coefficient of reliability (internal consistency) of the EBSQs was determined separately using Cronbach's alpha statistics. As such, Cronbach's alpha for the EBSQ was 0.83 within the acceptable range advocated by Tavakol and Dennick (2011).

### 3.4 Data Analysis

To proceed with data analysis, responses for ESBQ Likert-type items were categorised as naive, neutral, and sophisticated beliefs. A naive response did not correspond to the accepted beliefs of the scientific communities, while a neutral response held undecided beliefs. A sophisticated belief, on the other hand, constituted epistemic beliefs that corresponded to the accepted views shared by the scientific communities. Further, responses for the EBSQ were scored from 1 to 3, whereby sophisticated beliefs were scored 3, while naive beliefs were scored 1. The undecided beliefs, of course, were scored 2.

Data were analysed using descriptive and inferential statistical methods. As for the descriptive statistics, the categories of responses for each item and, of course, for dimensions especially in the context of teaching background were computed in terms of frequency (%). Further, the chi-square test of independence ($\chi 2$) was carried out to examine science teachers' EBS across each EBSQ dimension about their teaching background. The analysis of variance (one-way ANOVA) was computed to examine how science teachers' EBS are being moderated by their educational qualifications. These statistical tests were carried out using SPSS version 23.

## 4 Results

Findings from the study are reported in the following sections:

### 4.1 EBS Across the Dimensions

#### 4.1.1 Source Dimension

As shown in Table 1, Bhutanese primary science teachers increasingly believed in the authoritarian view of science. As could be seen, they firmly held a strong faith in scientists and scientific reports in all the aspects that reflect the *source* of scientific knowledge. Take, for example, a great bulk (81%) of Bhutanese primary science teachers typically expressed that "one must believe in the scientific reports", while 69.2% of them felt that people should agree with scientists. Not surprisingly, more than one-half (50%) of them endorsed the impression that regarded scientists and scientific reports as absolute authorities where scientific conclusions remain to be always true and certain.

**Table 1** Distribution of EBS across source dimension (%)

| Items | Naive | Undecided | Sophisticated |
|---|---|---|---|
| People have to believe in what scientists say | 69.2 | 8.7 | 22.1 |
| One must believe in the scientific reports | 81 | 7.7 | 11.3 |
| Whatever scientists say is true | 52.3 | 13.8 | 33.8 |
| Findings reported in scientific reports remains to be true | 60.5 | 12.8 | 26.7 |
| Scientists know for sure what is true in science | 63.6 | 12.3 | 24.1 |
| Big ideas in science often come from scientists | 63.6 | 14.9 | 21.5 |

#### 4.1.2 Certainty Dimension

As shown in Table 2, a large majority (68.2%) of Bhutanese primary science teachers felt that science, as in any sort of investigation, attempts to come up with one right answer, while an equivalent number (68.6%) of them agreed that "scientists believe in what is true in science". Strikingly, as it was seen in other aspects related to the *certainty* of scientific knowledge, almost close to or more than 50% of Bhutanese primary science teachers subscribed to the notions that exemplify the existence of one correct answer in science. Nearly one-half (43.1%) of them, for example, intuitively believed that all the "questions in science have one most correct answer".

#### 4.1.3 Development Dimension

Quite seemingly, as it appears in Table 3, a large majority (87.6%) of Bhutanese science teachers remained ascribing to the temporary nature of scientific knowledge. Many (95.4%) of them, as per their widely held notion, maintained that scientific ideas are subject to change in the face of new evidence. Nonetheless, despite considering science to be tentative, they reportedly held the typified notion that considered science as being absolute and certain. Take, for instance, 84.1% of them allegedly agreed with the statement that "some scientific ideas obtain proven status". As for this, many (96.4%) of them seemed to believe that scientific knowledge becomes stronger and attain the status of being more certain with the collection of evidence over time.

#### 4.1.4 Justification Dimension

It was quite encouraging that Bhutanese primary science teachers held sophisticated beliefs concerning the *justification* dimension of scientific knowledge. As can be seen in Table 4, almost all of them (94.9%), indeed, went on to say that scientific ideas are tested using

**Table 2** Distribution of EBS across certainty dimension (%)

| Items | Naive | Undecided | Sophisticated |
|---|---|---|---|
| Questions in science have one most correct answer | 43.1 | 18.5 | 38.5 |
| Scientific investigation is to come up with the right answer | 68.2 | 7.2 | 24.5 |
| Scientists know best about science than others | 56.9 | 11.9 | 31.3 |
| Scientific knowledge is always true | 53.8 | 16.4 | 29.7 |
| Scientists always agree about what is true in science | 68.6 | 16.0 | 15.5 |

**Table 3** Distribution of EBS across development dimension (%)

| Items | Naive | Undecided | Sophisticated |
|---|---|---|---|
| Some scientific ideas obtain absolutely proven status | 84.1 | 10.6 | 5.1 |
| Ideas in science change over time | 4.1 | 8.2 | 87.6 |
| Science become stronger with the collection of evidences | 96.4 | 1.5 | 2.1 |
| New evidences are the main reasons that change science | 95.4 | 2.6 | 2.1 |

more than one method. Similarly, a close proportion (96.9%) of them also felt that science deals with both creativity and imagination. On the contrary, they appeared to be clouded with mistaken beliefs in several aspects. One among these was their steadfast belief when 95.9% of them agreed that "answers in science often come from experiments". This typified belief, as it happened to be, was further supported by their subsequent response when almost all (93.8%) of them readily felt that "good answers are gathered from experiments". Thus, relatively, many (92.8%) Bhutanese primary science teachers openly admitted that scientific investigations, irrespective of scale and scope, are specially carried out to prove scientific claims and ideas.

## 4.2 EBS and Teaching Background

As was the case, Bhutanese primary science teachers' EBS related to their teaching backgrounds turned out to be very similar. In the *source* dimension, for instance, when more than one-half (60%) of them from a science teaching background reportedly held naive views, a similar proportion (64.8%) of them with a general teaching background also appeared to be clouded with naive views. Not surprisingly, in the *certainty* dimension as well, many science teachers from both teaching backgrounds remained settled with either naive or undecided beliefs. Because of this, while there was no evidence from science teaching backgrounds who seemed to possess correct EBS, there were only 4.2% of their counterparts from general teaching backgrounds indicated to possess sophisticated EBS. Sadly, even in the *development* dimension, it turned out that many science teachers were, in fact, exceedingly ignorant about the changing nature of scientific knowledge. For example, while there were only 1.2% of science teachers from a general teaching background, there were no individual science teachers from a science teaching background who appeared to maintain sophisticated EBS. Furthermore, comparable results were also observed in the *justification* dimension, too.

As science teachers from both teaching backgrounds (science and general) seemed to maintain a similar nature of EBS, the chi-square test of independence revealed no

**Table 4** Distribution of EBS across justification dimension (%)

| Items | Naive | Undecided | Sophisticated |
|---|---|---|---|
| Answers in science often come from experiments | 95.9 | 4.1 | 0 |
| There can be more than one method to test scientific ideas | 3.1 | 5.1 | 94.9 |
| Scientific investigations are carried out mainly to prove ideas | 92.8 | 4.1 | 3.1 |
| Creativity is part and parcel of science | 1.1 | 2.1 | 96.9 |
| Good answers are based on evidence gathered from experiments | 93.8 | 3.6 | 2.6 |
| Imaginations do not contribute in science | 52.8 | 13.8 | 33.3 |

**Table 5** Chi-square statistics

| Dimension | General ($N$) | Science ($N$) | $\chi 2$ value (chi-square) | $p$ value (sig.) |
|---|---|---|---|---|
| Source | 165 | 30 | 1.24 | 0.54 |
| Certainty | 165 | 30 | 2.02 | 0.37 |
| Development | 165 | 30 | 1.25 | 0.54 |
| Justification | 165 | 30 | 4.86 | 0.09 |

Level of significance: $^{*}p < 0.05$

**Table 6** ANOVA statistics

| | Mean scores | | | | *F value* | $p$ value (sig.) |
|---|---|---|---|---|---|---|
| | B.Ed. ($n = 156$) | PGDE ($n = 6$) | Master ($n = 8$) | Others ($n = 25$) | | |
| Source | 1.58 | 2.20 | 1.70 | 1.40 | 2.30 | 0.08 |
| Certainty | 1.55 | 2.01 | 1.63 | 1.33 | $3.96^{*}$ | 0.01 |
| Development | 1.61 | 1.71 | 1.66 | 1.55 | 0.93 | 0.43 |
| Justification | 1.92 | 1.91 | 1.83 | 1.88 | 0.38 | 0.77 |

Level of significance: $^{*}p < 0.05$

significant difference between Bhutanese primary science teachers' EBS based on their teaching background. As such, findings from the chi-square test of independence are shown in Table 5, such that *source* ($\chi 2(2) = 1.24$, $p > 0.05$), *certainty* ($\chi 2(2) = 2.24$, $p > 0.05$), *development* ($\chi 2(2) = 1.23$, $p > 0.05$), and *justification* ($\chi 2(2) = 4.86$, $p > 0.05$).

### 4.3 EBS and Educational Qualification

As shown in Table 6, the one-way ANOVA revealed that there were no significant differences among Bhutanese primary science teachers' EBS based on their academic qualifications. As such, for *source* ($F$ (3, 191) = 2.30, $p > 0.05$), *development* ($F$ (3, 191) = 0.93, $p > 0.05$), and *justification* ($F$ (3, 191) = 0.38, $p > 0.05$). However, the significant differences were observed in the *certainty* dimension such that $F$ (3,191) = 3.96, $p < 0.05$. In the post hoc analysis as shown in Table 7, the Tukey HSD test revealed the EBS of science teachers with PGDE qualification was significantly higher than their B.Ed. counterparts ($p < 0.05$). Similarly, the EBS of B.Ed. science teachers were significantly higher than their PTC colleagues ($p < 0.05$), while the EBS for PGDE science teachers were significantly higher than their PTC colleagues ($p < 0.05$).

## 5 Discussion

### 5.1 EBS Across the Dimensions

It was not encouraging as a large number of science teachers from three Bhutanese districts openly endorsed strict authoritarian beliefs of science. As per them, scientists and scientific reports always remain to be the best and true source of knowledge. These

**Table 7** Tukey post hoc test

| (I) Educational qualifications | (J) Educational qualifications | Mean difference (I-J) | Std. error | *Sig* | 95% confidence interval | |
|---|---|---|---|---|---|---|
| | | | | | Lower bound | Upper bound |
| B.Ed | PGDE | −0.462* | 0.191 | 0.017* | −0.839 | −0.084 |
| | Master | −0.082 | 0.167 | 0.622 | −0.411 | 0.246 |
| | Others (PTC) | 0.219* | 0.099 | 0.028* | 0.024 | 0.414 |
| PGDE | B.Ed | 0.462* | 0.191 | 0.017* | 0.084 | 0.839 |
| | Master | 0.379 | 0.248 | 0.128 | −0.110 | 0.869 |
| | Others (PTC) | 0.681* | 0.209 | 0.001* | 0.269 | 1.093 |
| Master | B.Ed | 0.082 | 0.167 | 0.622 | −0.246 | 0.411 |
| | PGDE | −0.379 | 0.248 | 0.128 | −0.869 | 0.110 |
| | Others (PTC) | 0.301 | 0.187 | 0.108 | −0.067 | 0.670 |
| Others (PTC) | B.Ed | −0.219* | 0.099 | 0.028* | −0.414 | −0.024 |
| | PGDE | −0.681* | 0.209 | 0.001* | −1.093 | −0.269 |
| | Master | −0.301 | 0.187 | 0.108 | −0.670 | 0.067 |

Level of significance: $*p < 0.05$

views are, indeed, naive as scientists and scientific reports are not the only rightful source of knowledge. Typically, but not necessarily, these beliefs must be a perpetuation of Bhutanese science curriculum documents; and the way science is largely conceived and taught in three Bhutanese districts. Instead, science by itself is not a dogmatism. Science, as elsewhere, turns to knowledgeable sources of information, including historians, sociologists, and philosophers, opens to ideas and opinions, and even considers daily observations and experiences as scientific knowledge. As such, this confirms the findings of the earlier studies conducted in Turkey (e.g., Sengul, 2024; Sengul et al., 2020), Taiwan (e.g., Liang & Tsai, 2010), and Singapore (e.g., Caleon et al., 2018). These international studies, however, have examined the authoritarian views of science in the contexts of science teachers and science textbooks.

Not surprisingly, as being clouded by naive epistemic beliefs, many science teachers maintained that there is one right answer to any scientific question. As such, they assumed that every scientific investigation, in any situation, is mainly carried out to prove one correct answer. Categorically, while attempts to achieve one correct answer are highly valued and desired in the scientific enterprise, it is by no means that science remains limited to one right answer. A rich history of science has, indeed, traditionally been to show that science, by itself, is never quite about finding one concrete explanation, but rather open to diverse alternative ideas and explanations that take up many forms. Similar views have also been expressed by Turkish science teachers (e.g., Bendixen & Corkhill, 2011; Sengul et al., 2020).

As revealed by Dorji et al. (2022) and Wangdi et al. (2019) in Bhutanese secondary science teachers, almost all the primary science teachers in this study believed scientific knowledge was tentative. This contemporary epistemic belief is especially sophisticated as scientific knowledge, though reliable and durable, never remains to be forever static and fixed (Lederman et al., 2002). Studies from Turkey (e.g., Aslan & Tasar, 2013) and Portugal (e.g., Torres & Vasconcelos, 2015) observed science teachers from these countries with similar informed views of science. On the other hand, Bhutanese primary science teachers from three districts in Bhutan believed in the proven status of scientific ideas. Moreover, they also mistakenly believed that scientific knowledge often becomes stable with the accumulation of evidence. Practically, as it has been, science never attains proven status nor becomes completely stable regardless of the mounting evidence (Lederman et al., 2002). Perhaps, these unsophisticated epistemic beliefs may rightfully serve as a set of cues as to how science, by itself, is reflected in the Bhutanese science curriculum documents or the way scientific investigations are conducted across the schools in three districts in Bhutan.

Interestingly, an overwhelming majority of Bhutanese primary science teachers considered creativity and imagination as integral parts of science while expressing that there is no single method in science. However, their sophisticated beliefs were quickly overshadowed by their subsequent beliefs that typified scientific experiments as recipes for all scientific endeavours. Categorically, it would be outrightly distorted to think of scientific experiments as algorithms for all scientific investigations, while scientific experiments in themselves do not represent all types of scientific investigations. Perhaps, these steadfast beliefs of science teachers from three Bhutanese districts could be a manifestation of their strong devotion pivoted towards mythical notions of the scientific method, while there is nothing such as a scientific method (Lederman et al., 2013, 2014). Moreso, these deeply entrenched notions might, indeed, serve to infer how scientific investigations are reflected in Bhutanese science curriculum documents or conceived and practised by primary science teachers in three Bhutanese districts. Primarily, it would be unpleasant and harmful if science in three Bhutanese districts or beyond is conceived and practised not much beyond the culture of scientific experiments. In reality, science is advanced using various methods, such as observation, description, and classification of organisms, events, and situations to understand phenomena and derive patterns (Eliyahu et al., 2020; Lederman et al., 2014; NRC, 2012). The notion that considers experiments as the supreme source of scientific knowledge was habitually expressed by science teachers in Portugal (Torres & Vasconcelos, 2020), Turkey (Mihladiz & Dogan, 2014), and Thailand (Buaraphan, 2013).

## 5.2 EBS to Teaching Background and Educational Qualification

### 5.2.1 Based on Teaching Background

The independent sample *t*-test indicated that there was no significant difference between Bhutanese primary science teachers' EBS based on their teaching backgrounds ($p > 0.05$). This finding, as it implies, seems to indicate that Bhutanese science teachers, whether from a science teaching background or a non-science teaching backgrounds, possess similar stances of EBS. Similarly, in the Hungarian context, Korom et al. (2023) found that teachers from both science and history groups held similar levels of EBS. Although this may not remain to be always the case, this finding in its rights appears to allude to the extent of how Bhutanese science teachers are being trained in the pre-service training colleges. Theoretically, many scholars from around the world agree that much of the science teachers' worldview of science, including the epistemic views of science, or the conceptions of science teaching is inherently moderated by the experiences acquired from the pre-service training (Dorsah et al., 2020; Korom et al., 2023; Wu et al., 2020). Thus, without much exception, it appears safe to assume that Bhutanese science teachers, both secondary and primary science teachers are trained with little or without much focus on the stances of EBS or for that matter NOS. What is more, the finding also appears to suggest that there are just no stances of EBS being considered in the pre-service training modules offered in the colleges of education.

At the same time, Bhutanese primary science teachers' naive views of EBS may also be explained in the context of science curriculum documents used across Bhutanese schools. Practically, both students' and science teachers' views of science, including that of EBS and NOS, are known to be influenced and shaped by what is reflected in science textbooks, teachers' manuals, or student guides (Abd-El-Khalick et al., 2008; Voitle et al., 2022; Wahbeh & Abd-El-Khalick, 2014). Typically, but not certainly, it may therefore be correct to assume that Bhutanese science teachers' narrow and distorted notion of EBS is usually explicitly perpetuated by science textbooks and other curricular documents. Connected to this argument, reports in the recent past consistently commented that science textbooks used across Bhutanese schools are rather content-focused that as a result tend to place less emphasis on epistemic aspects, such as learning through inquiry and scientific practices, understanding of the NOS itself (Dorji et al., 2020; Dorji et al., 2022). Hence, as all of these appear to make one line of argument, it can thus be argued that there is little to no indication of EBS in school science textbooks used by Bhutanese schools. Nonetheless, going by its scope, this current study can only have the leverage to speculate, while it cannot lend itself to verify empirically.

### 5.2.2 Based on Academic Qualification

As one-way ANOVA tests revealed a lack of significant differences among Bhutanese science teachers' EBS based on academic qualifications ($p > 0.05$), it indicates that Bhutanese science teachers with B.Ed., PGDE, masters' degree, or PTC qualifications held similar nature of EBS. Perhaps, this finding can be explained better and related further in the context of training or professional experiences accessed by science teachers. Practically, many reports from around the world repeatedly confirmed that science teachers' professional knowledge of science, including that of EBS and the NOS, tend to remain similar regardless of academic qualifications (Ajaja, 2012; Bruckerman et al., 2018; Dogan & Abd-El-Khalick, 2008). As for this, many scholars reportedly agree that the sophistication of EBS is not very relatable to academic qualifications but is rather dependent on the experiences gained by science teachers during pre-service or in-service training. That is if teachers receive training from or get exposed to the same curricula, same teachers, or same culture regardless of their academic qualifications, they usually end up understanding EBS or any other matters of science in question in a similar fashion (Adedoyin & Bello, 2017; Ajaja, 2012; Saif, 2016). Considering these theoretical perspectives, it seems possible that Bhutanese science teachers have neither received instruction nor experiences on EBS in their B.Ed., PGDE, or PTC pre-service training nor during the in-service programmes and master's courses later. Hence, this is one possible reason that could explain why Bhutanese science teachers with different levels of academic qualifications appeared to possess similar EBS.

## 6 Conclusions, Implications, and Limitations

This study examined the landscape of EBS held by Bhutanese primary science teachers from the *Tashigang*, *Zhemgang*, and *Wangduephodrang* districts. Findings revealed that primary science teachers from these districts held naive EBS in several aspects concerning *source*, *certainty*, *development*, and *justification* of scientific knowledge. Furthermore, the EBS possessed by these primary science teachers appeared to be neither influenced by their teaching background ($p > 0.05$) nor shaped by their academic qualifications ($p > 0.05$).

Given the findings, it looks genuine to correct EBS held by Bhutanese primary science teachers from three districts. As epistemic beliefs and theories remain inexplicably associated with science teachers' conceptions of teaching science (Fives & Buehl, 2016; Kampa, et al., 2016), epistemic theories may largely function as a basis for planning lessons and carrying out classroom teaching. Perhaps, a growing body of research acknowledges that teachers' EBS have direct implications on how students view science and learn science (Ho & Liang, 2015; Lee et al., 2016; Liang & Tsai, 2010). As for this, the MoE in collaboration with district education offices may take a lead role in organising training programmes to further the EBS of primary science teachers residing in three districts. The other important aspect, which is critical, is the close examination of EBS, including the aspects of NOS presented in Bhutanese science curriculum documents. As science teachers' distorted views of science, including EBS are known to be especially perpetuated by science curriculum documents (Abd-El-Khalick et al., 2008; Wahbeh & Abd-El-Khalick, 2014), it appears necessary to take stock of science curricular materials and optimise to reflect EBS accurately. The teacher training modules prevalent in the colleges of education in Bhutan may be examined and reviewed to incorporate the related aspects of EBS, if any. More often than not, it is widely agreed upon by international scholars that science teachers' epistemic beliefs of teaching science are, partially or wholly, shaped by what they receive from their pre-service training programmes (Dorsah et al., 2020; Korom et al., 2023; Wu et al., 2020).

While this study attempts to inform about the EBS held by Bhutanese primary science teachers from three specified districts, it lacks the strength to generalise its findings to the entire population of Bhutanese primary science teachers. Hence, future studies with similar scale and scope may examine EBS by involving a representative number of Bhutanese primary science teachers. Moreover, future studies may also attempt to make study findings more objective and reliable by examining EBS in greater detail using qualitative data.

**Acknowledgements** The authors wish to acknowledge the agencies and individuals who rendered support while collecting data. The authors also wish to acknowledge all the Bhutanese primary science teachers who participated in this study.

**Author Contribution** Both authors contributed to the study's conception and design. While the material preparation, data collection, and analyses were performed by Karma Dorji, the data interpretation was performed by Thinley Namgyel. The first draft of the manuscript was written by Karma Dorji, and both authors commented on the previous version of the manuscript. Both authors read and approved the final version of the manuscript.

**Funding** Open Access funding enabled and organized by CAUL and its Member Institutions

## Declarations

**Ethics Approval** The research was an observational study as it did not involve humans as the research subjects. Hence, ethics approval was not applicable.

**Informed Consent** Informed consent was obtained from all the primary science teachers who participated in the study.

**Competing Interests** The authors declare that they have no conflict of interest.

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