Exploring the Role of Epistemological Beliefs in Shaping Teaching and Learning Practices

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Abstract

Learning strategies and instructional practices are greatly influenced by epistemological views, which are ideas about the nature of knowledge and knowing. Students' learning techniques and learning outcomes are shaped by teachers' instructional practices, which are influenced by their epistemological ideas, as research has repeatedly shown. These ideas have an impact on students' comprehension of the material and are strongly related to their engagement, motivation, and future academic and professional paths. In this study, the epistemological beliefs of physical science teachers were investigated using the Epistemological Beliefs Assessment for Physical Science (EBAPS) survey instrument. Data were collected from four distinct groups of teachers (N = 173): three groups teaching at different types of schools (privately managed school, centrally administered public school, and state run government school) and one group teaching undergraduate (UG) and postgraduate (PG) college courses. In addition, undergraduate students (N = 86) from two colleges in Shimla, India, were included in the study. A preliminary examination of the gathered data is presented in this study. The findings show that neither the two undergraduate student groups nor any of the four teacher groups had extremely advanced or expert-like epistemic viewpoints. This emphasizes the necessity to explicitly address epistemological beliefs in teaching physical science. Differences observed between teachers and students' epistemological orientations suggest that instructional practices, curricular materials, and assessment structures may implicitly reinforce procedural and authority-driven perspective of scientific knowledge. In addition, the study explores how teachers' epistemological beliefs vary across gender and levels of teaching experience, contributing to a more nuanced understanding of epistemic orientations among science educators. The study underscores the need for teacher education and professional development programs to engage with epistemological dimensions of teaching and learning, and provides empirical evidence from an underrepresented Indian context, contributing to broader discussions on epistemic development in science education.

keywords Epistemological beliefs, concept survey, learner-centered

1 Introduction

In Indian classrooms, the pressure to complete a prescribed syllabus within a limited timeframe often compels teachers to prioritize rapid content delivery. Because of this, classroom instruction often becomes teacher-centered, with students positioned as passive recipients and teachers serving as the main source of knowledge. Students' pre-existing beliefs, assumptions, and perspectives about knowledge and learning are largely ignored in such instructional settings, where the assessment of students' prior understanding is typically limited to academic performance or examination scores. However, learning is a constructive process that is heavily impacted by learners' epistemological beliefs that is, their views about the nature of knowledge, knowing, and learning rather than just the accumulation of factual information. Research has consistently shown that meaningful learning occurs when new information is connected with learners' prior knowledge and their epistemological beliefs [1–2]. When students perceive scientific knowledge as fixed, certain, and transmitted by authority, they are less likely to engage in inquiry, critical thinking, or conceptual change. Conversely, students who view knowledge as evolving and justified through evidence are more likely to adopt deeper learning strategies and develop scientific reasoning skills. While considerable attention has been paid to teachers' epistemological beliefs, students' epistemological beliefs are equally important, particularly in the Indian educational context where examination-oriented practices dominate classroom culture. Students' beliefs about whether scientific ability is innate or improvable, whether knowledge is absolute or tentative and whether learning requires memorization or understanding directly influence how they approach learning tasks, respond to instruction, and engage with scientific concepts. Ignoring these beliefs may limit the effectiveness of pedagogical reforms aimed at promoting inquirybased and learner-centered science education. Several studies [3–4] have examined science teachers' epistemological beliefs and have provided substantial evidence that these beliefs significantly influence classroom practices [5–8]. Teachers' beliefs play a crucial role in shaping instructional goals and in determining how these goals are translated into lesson planning and classroom implementation [9–10]. It has been suggested that teachers holding constructivist epistemological beliefs are more capable of identifying students' alternative conceptions and addressing them effectively than teachers with empiricist beliefs [11]. In the context of on-going educational reforms, particularly those emphasizing conceptual understanding and scientific reasoning, attending to teachers' epistemological beliefs becomes essential, as these beliefs serve as a strong indicator of the nature and quality of classroom practices [12]. At the same time, examining students' epistemological beliefs alongside those of teachers provides a more comprehensive understanding of classroom dynamics and learning outcomes [13-18]. Such an approach is particularly relevant in the context, where diverse classroom settings, examination-oriented practices, and varying levels of exposure to inquiry-based learning often create a disconnect between teachers' instructional beliefs and students' learning beliefs, thereby significantly influencing students' engagement with science and their development as scientific thinkers. Several surveys have been created to assess the impact of epistemological beliefs on learning. These include the MPEX survey developed by Redish et al. [19], the VASS by Halloun and Hestenes [20], and the CLASS by Adams et al. [21]. These surveys are commonly referred to as attitude or affective surveys. In contrast, the Epistemological Beliefs Assessment for Physical Science Survey (EBAPS) by Elby et al. [22] specifically targets views and concepts related to the physical sciences. While numerous studies have explored teachers' beliefs and instructional approaches in Western contexts, empirical research in the Indian educational landscape remains scarce. Research on epistemology in science education has highlighted the role of learners' and teachers' beliefs about knowledge, knowing, and knowledge construction in shaping learning processes and instructional practices [23-24]. In the context of the physical sciences, epistemological constructs have been examined through various frameworks. Research on epistemological beliefs in the Indian physical sciences is limited but growing. Sharma, Ahluwalia, and Sharma (2013) examined both students' and teachers' beliefs in physics using the MPEX survey, finding that students often hold transitional or naïve beliefs emphasizing memorization, while teachers display a mixture of sophisticated and traditional orientations [25]. Sen and Karwande (2025) explored higher education teachers' epistemological beliefs, showing that although many teachers value conceptual understanding, classroom practices do not always reflect these beliefs [26]. Additional work from the epiSTEME conference series highlights epistemic practices in Indian science classrooms [27]. Despite these contributions, studies rarely examine teachers and students together or adopt a unified framework. Building on this prior work, the present study seeks to examine epistemological beliefs among both teachers and students within a shared analytical framework. By exploring role-specific patterns in beliefs about knowledge and learning, the study addresses gaps in existing Indian research, which typically considers either students or teachers in isolation. The findings are intended to inform both instructional practices and teacher education initiatives in the physical sciences, providing empirical evidence to guide future curriculum design and classroom interventions. This paper addresses this gap by presenting a study conducted using the EBAPS among distinct groups of science teachers in India. While prior research has examined epistemological beliefs of teachers in general, comparatively little attention has been paid to how these beliefs vary with demographic and professional factors such as gender and teaching experience, particularly within the Indian physical sciences context. Understanding these variations is important, as teachers' epistemological beliefs influence instructional practices, classroom discourse, and learning opportunities afforded to students. Accordingly, the present study explicitly examines teachers' epistemological beliefs with respect to gender and professional experience, alongside a comparison with students' beliefs. The remainder of the manuscript is organized as follows. Section 2 outlines the purpose of the study and the research objectives. Section 3 describes the methodology, Section 4 details the survey dimensions and the methodology used to assign weightage to individual question items. Section 5 presents the data analysis and results. Section 6 concludes the paper by summarizing the key findings, discussing implications, and finally Section 7 outlines directions for future research.

2 Purpose of Study

The purpose of the present study is to investigate epistemological beliefs concerning the nature of knowledge and learning in physical sciences among teachers across multiple educational levels (school, college, and university) and among undergraduate students. Using the Epistemological Beliefs Assessment for Physical Science (EBAPS), the study examines how participants conceptualize scientific knowledge, knowing, and learning, and evaluates the extent to which these beliefs correspond with expert perspectives in the discipline.

Research Questions The study is guided by the following research questions:

1. What epistemological beliefs about physical science and the learning of physical science are held by school teachers and faculty teaching at undergraduate and postgraduate levels in colleges and universities?

2. What epistemological beliefs about physical science and learning are held by undergraduate students?

3. To what extent do the epistemological beliefs of teachers and undergraduate students align with expert views of knowledge and learning in the physical sciences, as operationalized within the EBAPS framework?

3 Methodology

The present study employed a survey research design using the Epistemological Beliefs Assessment for Physical Science (EBAPS) to examine epistemological beliefs among teachers and students. The sample was drawn from selected school and higher education institutions in Shimla, Himachal Pradesh, India. The teacher sample comprised educators teaching at the Grade 12 level as well as faculty members teaching at the undergraduate (UG) and postgraduate (PG) levels. Grade 12 teachers were selected from three types of schools: a privately managed school, a centrally administered public school, and a state government run school. In addition, college and university faculty members teaching at the undergraduate and postgraduate levels were included. Details of the teacher sample are presented in Table I. The student sample consisted of third year undergraduate students from a women's degree college and of a public co-educational college located in Shimla, Himachal Pradesh, India (see Table II for sample details)

Table I: Details of the Sample of Teachers

School/College	Class Taught	Male	Female	Total
Teachers from privately managed school	Grade 12	40	10	50
Teachers from centrally administered public school	Grade 12	38	9	47
Teachers from state run Govt. school	Grade 12	32	4	36
Teachers from colleges and universities	UG & PG	34	6	40

Table II: Details of the Sample of Students

College	Class/Year	Male	Female	Total
Women's degree college	B.Sc. III	–	53	53
Public co-educational college	B.Sc. III	23	10	33

4 Survey Dimensions and Methodology of Weightage For Each Question Item

The Epistemological Beliefs Assessment for Physical Science (EBAPS) is a 30-item instrument designed to assess students' epistemological beliefs in physical science. Items include agree/disagree statements, multiple-choice questions, and debate items rated on a five-point Likert scale (0–4). The survey measures five epistemological dimensions. Structure of Scientific Knowledge evaluates whether science is perceived as a coherent body of knowledge or as disconnected facts. Nature of Knowing and Learning examines beliefs about learning as passive reception versus active knowledge construction. Real-Life Applicability assesses the perceived relevance of science beyond academic settings. Evolving Knowledge addresses views of scientific knowledge as fixed or subject to change through evidence-based inquiry. Source of Ability to Learn explores whether scientific ability is considered innate or developable through effort. Table III presents the item distribution across the five dimensions. Following EBAPS scoring guidelines, item scores (0=least sophisticated; 4=most sophisticated) were aggregated by dimension and multiplied by 25 to rescale each axis to a common 0–100 metric. This standardization ensures comparability across dimensions with unequal item counts and enhances interpretability without altering the relative weighting of items. The overall EBAPS score was calculated as the mean of the five axis scores to yield a composite measure of epistemological sophistication consistent with the instrument's theoretical framework. Learners' epistemological beliefs are commonly categorized as naïve or sophisticated [28]. Naïve beliefs reflect views of knowledge as certain, authority-based, and independent of effort, with ability perceived as fixed. Sophisticated beliefs emphasize the evolving, constructed nature of knowledge and the role of effort in learning. Consistent with prior studies, mean scores below 3 indicate naïve beliefs, while scores above 3 represent expert-like epistemological perspectives [29]. These criteria were adopted in the present study.

5 Data Analysis and Results

In the following section, we present the analysis of the gathered data and look at it in different ways: (5.1) Axis-wise, (5.2) Overall, (5.3) Experience-wise, and finally (5.4) Gender wise. As explained earlier, the EBAPS survey, a benchmark score of 3 represents the threshold between naïve and sophisticated epistemological beliefs. Because individual items are scored on a 0–4 scale, a mean score of 3 indicates consistent endorsement of expert-like responses across items within a given dimension. Scores below 3 reflect predominantly naïve or transitional beliefs, characterized by views of knowledge as fixed, authority-driven, and weakly connected to effort or

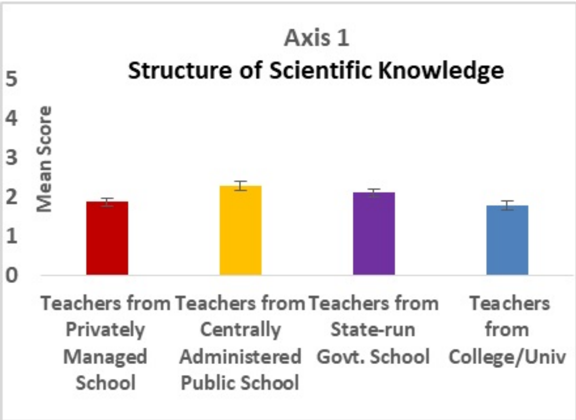
Table III: Dimensions of Five Axes in EBAPS

Axis	Axis Title	Dimension of Axis	Question items pertaining to each axis
Axis1	Structure of Scientific Knowledge *(coherent vs. pieces)*	Whether science is perceived as a coherent, unified body of knowledge or as a grouping of disconnected facts and formulae?	(2, 8, 10, 15, 17, 19, 20, 23, 24, 28)
Axis2	Nature of Knowing and Learning *(propagating from authority vs. self-constructed)*	Does learning science mean absorbing facts or constructing knowledge from prior knowledge, working with materials, and reflecting?	(1, 7, 11, 12, 13, 18, 26, 30)
Axis3	Real-Life Applicability *(applicable vs. non-applicable to real life)*	Can science apply only to a classroom or laboratory, or does it apply more generally to real life?	(3, 14, 19, 27)
Axis4	Evolving Knowledge *(absolute vs. changing)*	Is knowledge absolute, evolving as often as people's beliefs, or changing in a structured, research-based manner?	(6, 28, 29)
Axis5	Source of Ability to Learn *(inherent vs. acquired)*	Does being good at science result from natural ability, or can most people become better at learning and doing science?	(5, 9, 16, 22, 25)

real-world contexts. In contrast, scores at or above 3 signify sophisticated epistemological perspectives, including recognition of the evolving nature of scientific knowledge, active knowledge construction, and the role of effort in learning. Accordingly, the benchmark of 3 is used in this study to distinguish non-expert from expert-like epistemological orientations, consistent with prior EBAPS-based research.

5.1 Axis-wise Analysis

Axis 1 Structure of Scientific Knowledge This dimension probes whether individuals view science as a unified, cohesive entity or as a mere collection of disjointed facts and formulas. The average score across all



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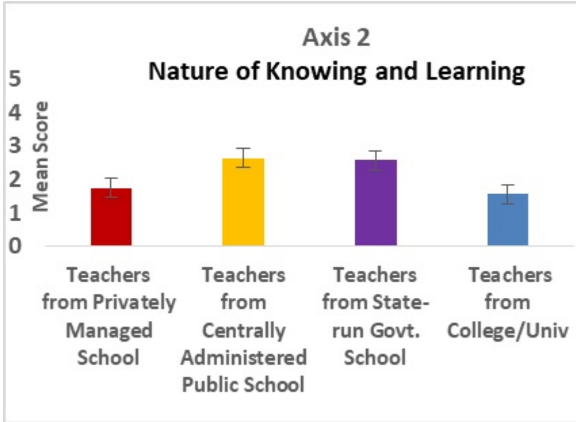

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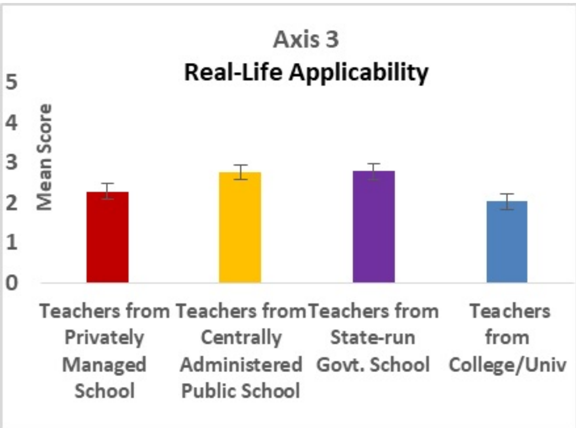

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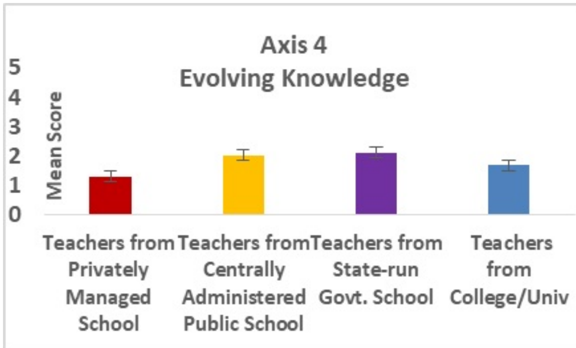

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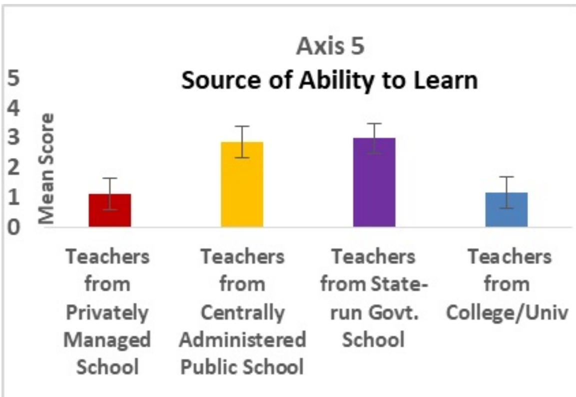
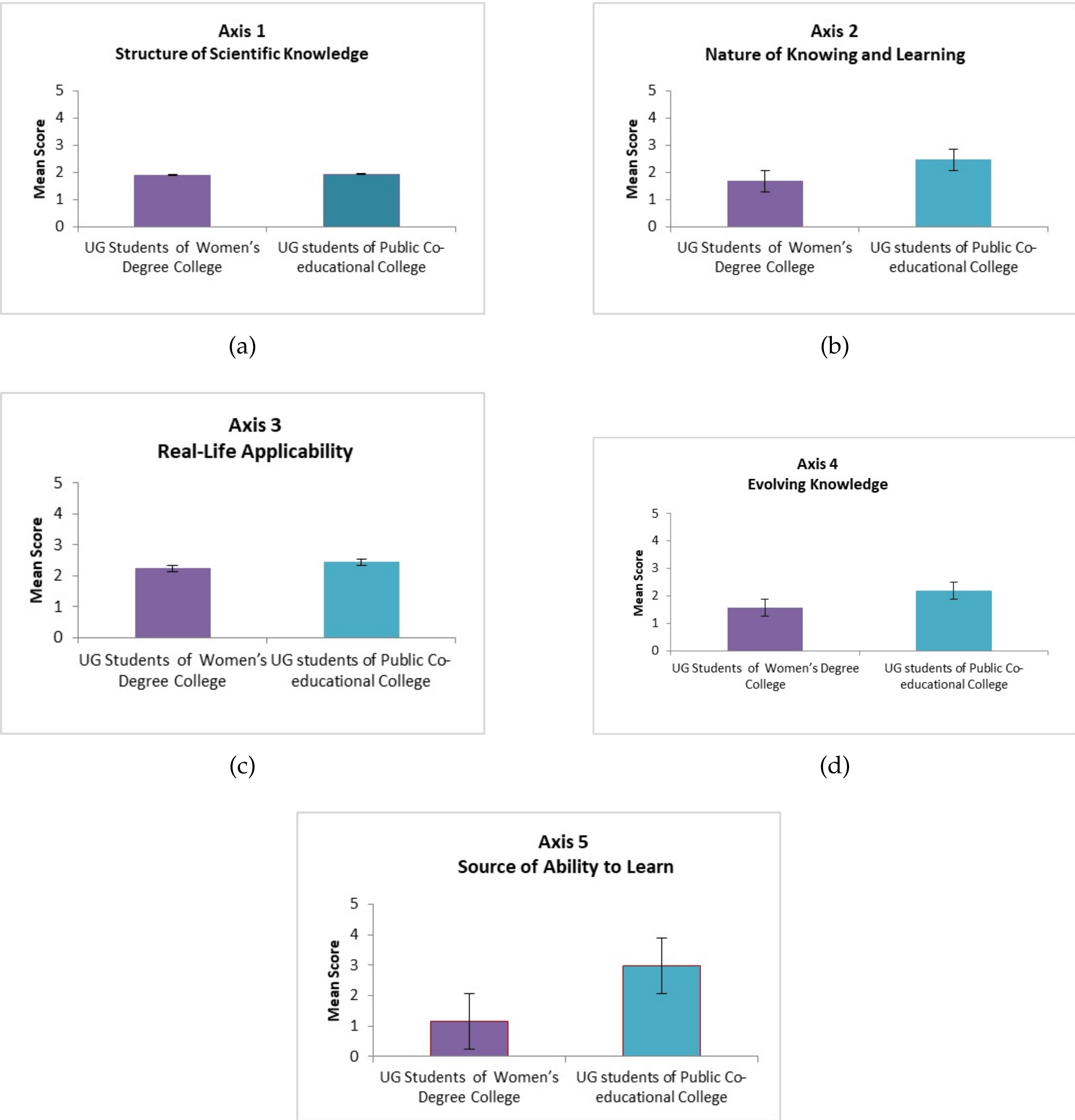


(e)

Figure 1: Axes-wise results of EBAPS for **teacher** samples.

fourteacher groups depicted in Figure 1a was found to be below 3, indicating a preva-



(a) (b) (c) (d) (e)

Figure 2: Axes wise result of EBAPS for **students** samples

lent tendency among teachers to perceive scientific knowledge in fragmented terms. Similarly, when examining undergraduate students, as illustrated in Figure 2a, those from both public co-educational college and from a women's degree college scored below 3. This suggests neither cohort exhibited an expert-like or sophisticated perspective regarding the coherence and structure of knowledge. Rather, both teachers and students tended to view knowledge as comprising discrete elements, characterized primarily by the memorization of facts, formulas, and isolated pieces of information.

Axis 2 Nature of Knowing and Learning In axis 2, the question arises: is learning science merely about passive absorption of facts, or is it about actively constructing knowledge through the integration of prior knowledge, hands-on engagement with materials, and reflective practice? The findings from both groups of teachers and students, as depicted in Figures 1b and 2b, respectively, indicate a mean score below 3. This suggests that a significant portion of both teachers and students perceive learning science as primarily centered around the passive absorption of information, rather than an active process of constructing personal understanding.

Axis 3 Real-Life Applicability Axis 3 examined beliefs related to the reallife applicability of science, specifically whether science is perceived as limited to classroom or laboratory settings or as extending to everyday contexts. The mean score obtained for this axis (Fig. 1c), across four groups of teachers, showed a slight improvement compared to the other axes; however, it remained below the expert-like benchmark of 3. Teachers from state-run government schools and centrally administered public schools scored nearly at the expert-like level, whereas teachers from privately managed schools and college-level institutions scored substantially lower. Similarly, the mean score for undergraduate students on this axis (Fig. 2c) also remained below 3.

Axis 4 Evolving Knowledge In axis 4, which explores whether knowledge is absolute or constantly evolving based on people's beliefs or structured research, the mean score among all groups of teachers was notably low (see Fig. 1d). Similarly, in the case of students (see Fig. 2d), the mean score for both colleges was below 3. These results suggest that both teachers and students found it challenging to grasp the concept that science is a dynamic process continually enriched by advancements in knowledge and learning.

Axis 5 Source of Ability to learn
Axis 5 addressed beliefs concerning the origin of scientific proficiency, specifically whether competence in science is viewed as an innate ability or as a skill that can be developed through effort and exposure. The mean scores of teachers from state-run government school and centrally administered public school were close to the expert-like level (Fig. 1e), reflecting a belief that most individuals can improve their scientific learning and skills through effective study strategies. Such beliefs may positively influence students by fostering motivation to engage with scientific disciplines. In contrast, the mean scores of UG/PG level teachers and teachers from privately man-

aged school were considerably lower, suggesting a tendency to view scientific aptitude as largely innate and less amenable to development over time. Students' responses on this axis are presented in Fig. 2e. Undergraduate students from public co-educational college demonstrated beliefs closer to the expert-like perspective, whereas students from the women's degree college scored substantially lower. Indicating different perceptions about whether the ability to learn science can be developed. Table IV and Table V present the descriptive statistics (Mean ± Standard Deviation) and one-way ANOVA results for the five axes across all the teachers' groups and students' groups. From the Mean ± SD table it is observed that Axis 3 consistently exhibited higher mean values across all groups, suggesting it represents a strongly developed or widely agreed upon dimension. In contrast, Axis 5 showed substantial variability, with notably higher scores in centrally administered and government school teachers as well as co-educational college students, but lower scores among private school, teachers from colleges and universities and students from women's degree college. This might be possible system-level or training-related differences or variation in exposure, resources, or pedagogical practices.

Table IV: Descriptive Statistics (Mean $\pm$ SD) for Teachers and Students Groups (rounded to two decimal places)

	Teachers from Privately Managed School	Teachers from Centrally Administered Public School	Teachers from state run Govt. Schools	Teachers from Colleges and Universities	Students from Women's Degree College	Students from Public Co-educational College
Axis 1	1.87 ± 0.60	2.29 ± 0.53	2.11 ± 0.45	1.76 ± 0.48	1.90 ± 0.49	1.93 ± 0.32
Axis 2	1.75 ± 0.45	2.67 ± 0.39	2.58 ± 0.50	1.56 ± 0.55	1.66 ± 0.62	2.46 ± 0.46
Axis 3	2.29 ± 0.85	2.86 ± 0.74	2.78 ± 0.70	2.04 ± 0.79	2.30 ± 0.83	2.47 ± 0.73
Axis 4	1.32 ± 0.67	2.04 ± 0.93	2.13 ± 0.75	1.73 ± 0.93	1.55 ± 0.83	2.14 ± 0.66
Axis 5	1.13 ± 0.47	2.86 ± 0.77	2.98 ± 0.60	1.16 ± 0.47	1.15 ± 0.60	3.00 ± 0.63

The analysis of mean scores across five axes revealed a consistent pattern of variation across the axes, irrespective of institutional context. A one-way ANOVA indicated statistically significant differences among the axes in every dataset (p ¡ 0.001), confirming that the observed variations are not due to chance. Furthermore, the magnitude of differences, as reflected by F-values ranging from 8.54 to 27.21, indicates considerable variability across axes, particularly among private school teachers. These findings highlight both common trends and institutional differences in the measured constructs.

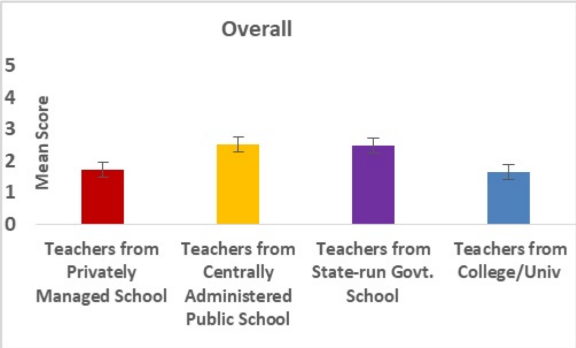
Table V: One-way ANOVA Summary for Teachers and Students Groups

Dataset	F-value	p-value	Significance
Teachers from Privately Managed School	27.21	1.07×10^{-18}	Significant
Teachers from Centrally Administered Public School	9.72	2.1×10^{-7}	Significant
Teachers from state run Govt. Schools	13.25	1.57×10^{-9}	Significant
Teachers from Colleges and Universities	8.54	2.1×10^{-6}	Significant
Students from Women's Degree College	9.30	2.8×10^{-7}	Significant
Students from Public Co-educational College	13.67	3.2×10^{-9}	Significant

5.2 Overall Analysis

Figures 3a and 3b indicate that:

- The overall mean score across all four groups of teachers was below 3, indicating that none of the groups approached expert-like or highly sophisticated views.
- Among the teacher groups, those from centrally administered public schools and state-run government schools obtained the highest mean scores across all axes as well as overall; however, these scores still did not reach the expert-level benchmark..
- Teachers from privately managed schools and from colleges/universities exhibited consistently similar mean scores across all axes and overall, and these scores were markedly lower than expert-like levels.
- For undergraduate students from both public co-educational college and from a women's degree college, the mean scores across all axes remained below 3.



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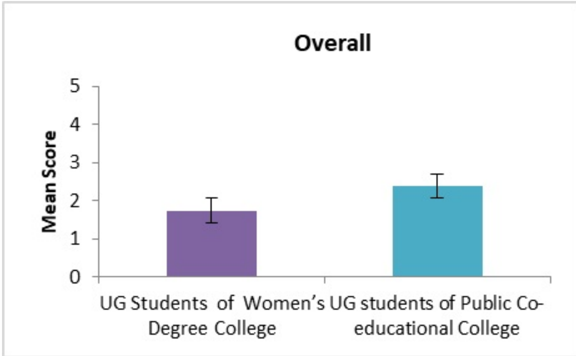


(b)

Figure 3: Overall result of teachers and students in EBAPS

5.3 Teaching Experience vs. Beliefs Analysis

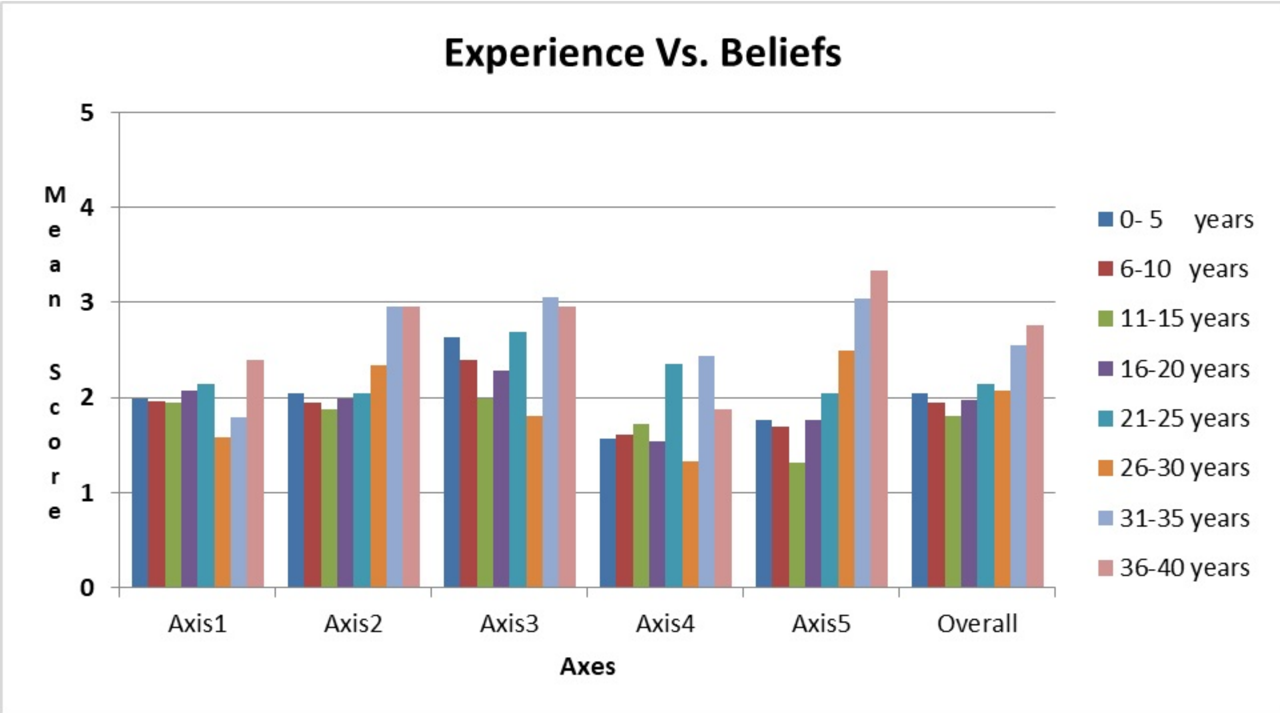
Figure 4 gives the mean score of teachers holding different levels of teaching experience and showing a clear impact of teaching experience in acquiring expert-like views.

- The mean score of the teachers with an experience of more than 30 years was highest in almost all the axes, as well as overall.
- In axes 2, 3, and 5, teachers with vast years of experience, i.e., (36-40), had a mean score near 3, showing their expertlike beliefs.
- In axes 1 and 4, the mean score of all the groups was very low, irrespective of the years of experience

The result obtained above indicates that focused interventions are needed at the beginning of a teacher's career to sensitize them to the nature of science and the epistemology of scientific knowledge. While accurate content delivery is important, fostering scientific thinking and promoting inquiry-based learning in the classroom are equally critical. If left unaddressed, misconceptions or naïve epistemological beliefs may negatively influence instructional practices. Therefore, early and deliberate support in this area is vital to ensure that teachers develop a well-informed and reflective approach to science education.

5.4 Gender wise Analysis

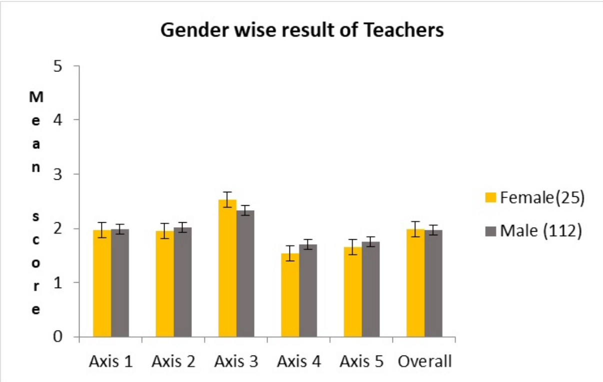
The gender comparisons of teachers' and students' epistemological beliefs are presented in Figures 5(a) and 5(b). By identifying systematic gender differences, the study highlights underlying belief patterns that may subtly shape classroom dynamics and learning outcomes. The findings reveal that female teachers scored lower than their male counterparts in Axes 1, 2, 4, and 5. This suggests that female teachers tended to



(a)

Figure 4: Experience vs. Beliefs result

lean more towards the belief that a person's ability is innate or fixed compared to male teachers. It raises important questions about how beliefs develop within professional and sociocultural contexts. This challenges common assumptions and suggests that epistemological beliefs are not merely individual traits but are influenced by broader structural, cultural, and institutional factors. Understanding these patterns is essential for designing targeted professional development that addresses belief systems, not just teaching techniques. Conversely, male teachers scored lower than female teachers in Axis 3, indicating a tendency towards naïve beliefs when relating subjects to real-life experiences. Identifying gender-linked tendencies in this dimension allows teacher educators and curriculum designers to intervene more precisely, strengthening contextual teaching approaches where needed. Among undergraduate students, females scored lower than males in all axes except Axis 1. It suggests potential differences in how male and female students conceptualize knowledge and learning during formative academic years. Gendered patterns appearing at both levels suggest that epistemological beliefs may be socially reinforced over time, rather than emerging in isolation. This underscores the need for early and sustained educational interventions that promote sophisticated, flexible, and growth-oriented epistemological beliefs across genders.



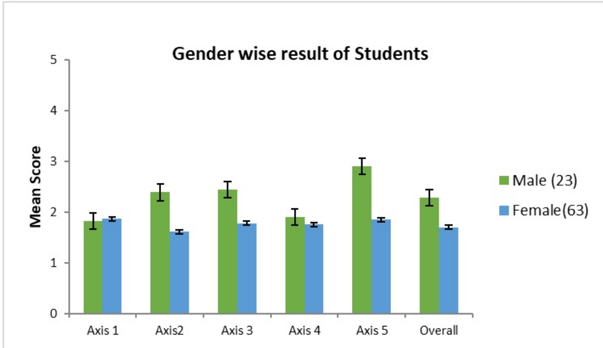


Fig. 5. Gender-wise comparisons of teachers' and students' epistemological beliefs.
(a) Teachers (b) Students

6 Conclusions

Epistemological beliefs offer important insights into both teaching and learning processes, because of that they have drawn a lot of attention in the academic literature within the education community. While students' beliefs influence how they approach learning tasks, interpret scientific knowledge, and participate in scientific inquiry, teachers' beliefs have an impact on instructional practices. Therefore, comprehending both viewpoints is crucial to enhancing science instruction. Using the Epistemological Beliefs Assessment for Physical Science (EBAPS) survey, which focuses on beliefs about the nature, acquisition, and comprehension of scientific knowledge, this study investigated the epistemological beliefs of teachers and undergraduate science students. Preliminary analysis indicated that both teachers and students predominantly perceived scientific knowledge as the memorization of facts, formulas, and discrete pieces of information. Additionally, participants in both groups found it difficult to understand how scientific knowledge is applicable and relevant in daily life. However, both teachers and students thought that improved study techniques and consistent effort may lead to success in learning science. Despite this belief in effort, neither teachers nor students exhibited the epistemological perspectives that are indicative of sophisticated or expert-like scientific understanding. These ideas may cause students to use superficial learning techniques, interact with concepts less, and have trouble applying what they've learned to new or real-world situations. These ideas may limit teachers' ability to educate, favoring fact-based methods over inquiry-based or conceptual learning opportunities. Thus, epistemological assumptions are crucial in determining how education is shaped as well as how students learn, how motivated they are, and how they view scientific literacy. The results highlight the necessity of prompt and deliberate interventions aimed at both educators and learners. While instructional strategies and curriculum designs at the undergraduate level should specifically support students' understanding of science as a dynamic, interconnected, and meaningful enterprise, professional development initiatives should assist teachers in developing more sophisticated epistemological perspectives. Efforts to improve the quality of science education and learning results are likely to remain limited if epistemological views on both sides of the classroom are not addressed.

7 Future Directions

This study provides an opportunity to learn about physical science teachers' and students' epistemological beliefs, but the fact that it includes responses from participants from only few institutions makes generalizations difficult. Further studies might apply larger institutionally connected samples, mixed-method approaches, or longitudinal designs to explore how epistemological beliefs develop and relate to teaching. This type of work can also help to inform teacher education, curriculum development and classroom interventions aimed at promoting more sophisticated epistemic orientations in science education.

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