Journal of Psychological Perspective. 2026; 8(3): 131-142
ISSN 2502-4825 (print), ISSN 2502-9495 (online)
DOI: 10.47679/jopp.8314772026

RESEARCH ARTICLE

Exploring the Role of Problem-based Learning in Fostering the Epistemological Beliefs of Psychology Students: A One-Group Pretest–Posttest Study

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Available online: 22 June 2026

Abstract
Psychology students must acquire sophisticated epistemological beliefs when engaging with evolving, ill-structured problems. The fast-paced progress in Artificial Intelligence (AI) and its psychological influence on human lives is one such ill-structured problem. This study examined the impact of problem-based learning (PBL) on epistemological beliefs by comparing pre-test and post-test scores acquired via the Epistemological Belief Inventory (EBI). Data were gathered from a convenience sample of 29 psychology students at a central university in the Indian state of Madhya Pradesh. A paired-samples *t*-test was employed to compare the pre-test and post-test mean values, and retrospective semi-structured interviews were conducted after the PBL intervention to supplement and corroborate the EBI results. The paired samples *t*-test indicated that there was a significant improvement in epistemological beliefs from pre-test (M = 115.7, SD = 14.7) to post-test (M = 67.9, SD = 9.5), following the PBL implementation, $t(28) = 15.3$, $p < .001$. The findings suggest that when students engage with complex, unstructured topics like AI and its psychological ramifications, PBL significantly strengthens their epistemological beliefs. The pedagogical value of PBL is highlighted by its capacity to promote more complex ways of knowing and reasoning.

Keywords: Artificial Intelligence; Epistemological Beliefs; Ill-structured problem; Problem-based learning

INTRODUCTION

The burgeoning developments in artificial intelligence (AI) pose multifaceted challenges to human life, even though AI has been making daily tasks easier, improving workflows, and automating processes (Kaličanin et al., 2019). Machines empowered with AI can perform multiple tasks simultaneously and continuously without breaks–unlike human labour–and serve as an effective alternative for reduce human error (Dilmegani, 2022). The accuracy level, speed, and scale of tasks AI performs are far better than those achieved by humans (Abrams, 2021).

Unlike a mathematical equation, AI-generated output is probabilistic and often ambiguous, necessitating that students to evaluate "certain knowledge". It is driven by next-token prediction rather than authentic information retrieval. AI models frequently generate statistically plausible information rather than authentic truth, hallucinating information like fabricated sources and providing superficial syntheses (Boretti, 2026). Consequently, navigating AI-generated outputs requires sufficient AI literacy and epistemic cognition, defined as the cognitive capacity to reliably engage in epistemic processes and ideals to reach epistemic ends like truth and genuine information.

Traditional, lecture-based pedagogy often triggers the passive consumption of knowledge. Such passive listening prevents students from engaging in higher-order thinking (Klein et al., 2023). Conversely, students need to possess sophisticated epistemic beliefs to effectively address the ambiguities of AI, actively constructing and critically examining the ill-structured nature of generative AI outputs.

Algorithms in artificial intelligence are not immune to biases and vested interests, as they are designed and executed by humans. Their values, assumptions, and biases can significantly influence the functioning of AI (Kartal, 2022). Tensions are arising regarding the potential influence of the pervasive presence of artificial intelligence-driven technology on the epistemic engagements of human beings. The ambiguous line between the advantages and disadvantages of artificial

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Submitted: 23 February 2026 Revised: 01 May 2026 Accepted: 31 May 2026

intelligence renders this tension an ill-structured problem. Ill-structured problems are prevalent in real-world contexts, and, unlike well-structured problems, lack clear-cut or definitive answers; consequently, there can be multiple ways of analysing the problem (Staff, 2017). Solving ill-structured problems is a crucial intellectual skill and a significant learning outcome (Jonassen, 2000; McNaughton, 2018).

The newly developed ChatGPT platform can provide instant epistemic outputs without requiring deep cognitive contemplations. If a student wants an assignment done, ChatGPT can provide a structured assignment format without the student carefully considering multiple search results, as is usual with standard Google searches. Searching through numerous information sources has long been considered one of the most reliable methods for reaching a sophisticated epistemic end (Chinn et al., 2014). However, the advent of AI-empowered platforms like ChatGPT poses many ill-structured problems regarding whether they negatively affect epistemic cognition.

Tensions are arising regarding the potential influence of the pervasive presence of artificial intelligence-driven technology on the epistemic engagements of human beings, as the ambiguous line between the advantages and disadvantages of artificial intelligence renders this tension an ill-structured problem. Ill-structured problems are prevalent in real-world contexts (Li et al., 2026). Unlike well-structured problems, ill-structured problems lack a clear-cut, obvious answer; consequently, there can be multiple ways of analysing the problem (LaSota, 2017). Solving ill-structured problems is a crucial intellectual skill and a significant learning outcome (Jonassen, 2000; McNaughton, 2018).

The problem-based learning (PBL) approach has proven effective in dealing with ill-structured problems (Geirsdotter Bækkelund et al., 2025). Therefore, the current article attempts to explore the influence of this approach in enhancing the epistemological beliefs of psychology students regarding the ill-structured nature of AI output on human cognition. Psychology students deal with human behaviour—a field where "Simple Knowledge" (one right answer), certain knowledge, and omniscient authority are rare. They must learn to synthesize conflicting theories and ambiguous information, making them a critical demographic for epistemic study. While existing literature explores the influence of PBL in clinical settings, there is a dearth of research on how PBL influences the epistemic crisis stimulated by generative AI in the social sciences.

While previous literature has explored the correlation between PBL and higher-order thinking skills, it remains unclear how a targeted PBL intervention can influence the epistemic crisis introduced by ambiguous tensions regarding the relationship between AI and human cognition. The current study addresses this research gap by exploring the role of a PBL intervention in influencing epistemic cognition among psychology students encountering an ill-structured problem regarding AI and human cognition.

Early researchers attempted to employ well-structured problems to derive general problem-solving strategies (Ernst & Newell, 1971; Newell & Simon, 1972). The general problem-solving strategies identified in those studies were applied to individuals to make them more efficient problem solvers. Nevertheless, these strategies were context-independent and rarely applicable to novel, real-world situations (Glaser & Chi, 1988; Pressley et al., 1987). In other words, there was a need to implement problem-solving strategies within the context of real-life, ill-structured problems. The problem-based learning (PBL) approach has proven effective in dealing with ill-structured problems (Geirsdotter Bækkelund et al., 2025). The PBL instructional model aims to improve problem-solving skills and foster higher-order thinking within the learning process (Abdalla & Gaffar, 2011). Furthermore, PBL positively impacts epistemological beliefs (Belland et al., 2019; Geirsdotter Bækkelund et al., 2025).

MATERIALS AND METHODS

Research design

The study employed a one-group pretest-posttest design accompanied by a qualitative follow-up. This pattern allowed for the quantification of changes in epistemic cognition while utilizing semi-structured interviews to delve deeper into the lived experiences of the participants.

Participants and sampling

Participants in the study consisted of 29 psychology university students at a central university located in Madhya Pradesh. The participants were selected based on a convenience sampling method.

Demographics

The sample consisted of 20 females and 9 males, with a mean age of 19.5 years (*SD*= 1.5). All the participants were in their fourth semester (second year) of their B.Sc. in Psychology.

Prior experience

Preliminary screening indicated that while 92% of participants had used Generative AI (ChatGPT) for basic search purposes, none had prior formal experience with epistemic reflexivity training or Problem-Based Learning (PBL).

Inclusion and Exclusion criteria

Inclusion required a minimum of 75% attendance in the previous semester. Participants with formal exposure to any philosophy of science or logic electives were excluded from the research to minimize bias in their baseline epistemic sophistication.

We selected participants from the psychology domain because psychological interventions in evolving artificial intelligence research are necessary (Abrams, 2021; Rowley, 2023). Even though psychologists are involved in developing therapeutic chatbots and face-recognition mechanisms employing artificial intelligence (Abrams, 2021), confusion exists regarding whether AI is entirely immune to posing psychological threats to human well-being. One vital research area is the malicious use of AI (MUAI) in psychologically destabilizing political systems (Bazarkina & Pashentsev, 2019). Although AI intervention can provide optimal medical care, more negative emotions have been observed among patients when AI is involved in their care (Zhou et al., 2022).

It is a paradoxical reality that although people generally perceive external entities, such as interacting with technology and machines, as a threat to human tasks, the rapid advancement of artificial intelligence and subsequent addictive digital experiences are becoming more prevalent and challenging to resist for human beings (Chianella, 2021; Granulo et al., 2019). The internet is

becoming a threat to sophisticated epistemological endeavours as it functions as an echo chamber where our deeply held beliefs and notions are continually self-reinforced. Algorithms prioritize information we previously favoured instead of presenting multiple knowledge perspectives, thus polarizing and radicalizing our engagements with the epistemological process (Inazu, 2016; Sunstein, 2002). Thus, psychology students should possess a sophisticated epistemological understanding while they engage with knowledge-producing processes related to artificial intelligence and its interaction with human lives.

Nature of the study

The present study seeks to address the following research question: Does the introduction of a problem-based learning (PBL) instructional model positively influence epistemological beliefs? We formulated the following hypothesis based on extant literature substantiating the positive causal influence of the PBL model in fostering these beliefs: Students exposed to a Problem-Based Learning instructional model will show an increase in epistemological belief scores on the Epistemological Beliefs Inventory (EBI) from pre-test to post-test.

Data collection

Epistemological belief inventory

One day before and after the administration of PBL, students completed the Epistemological Beliefs Inventory (EBI). The inventory assesses five dimensions of epistemological beliefs: whether knowledge is (a) simple, (b) certain, (c) innately determined, (d) derived from omniscient authority, and (e) quickly learned. Students were given the inventory developed by Schraw et al. (2002), which consisted of 32 items using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Example items include, "Children should be allowed to question their parents' authority" and "I like teachers who present several competing theories and let their students decide which is best." Seven items were reverse-coded. The EBI has higher test-retest reliability than the Epistemological Questionnaire developed by Schommer (Bendixen et al., 1998; Schommer, 1990). As the study was conducted in a non-western linguistic context, two independent bilingual Psychologists engaged in a forward-backward translation process of the EBI to ensure comprehension of the items by the participants. A Pilot study with five individuals (n= 5) ensured the face validity. The adapted scale showed an acceptable level of internal consistency (Cronbach's α= .81).

Semi-structured retrospective interviews and data analysis

Following the post-test, a subsample of 13 students participated in individual 20-minute interviews. The participants were selected using maximum variation sampling (anchored on the highest and lowest changes in EBI scores). The participants' native language was used to conduct the interviews to ensure depth of expression. All sessions were audio-recorded and transcribed verbatim with the prior permission of the participants. The sessions explored whether the one-on-one scaffolding during Problem-Based Learning (PBL) provided benefits during each self-directed learning phase of PBL and whether participants identified any other cogent, reliable ways to reach the most appropriate solution while processing knowledge. Example questions included: "Do you think searching multiple knowledge sources or just asking ChatGPT about the solution is more reliable?", "Can you successfully find a solution when you experience negative emotions?" and "Which will provide better solutions: engaging open-mindedly with multiple perspectives or agreeing with your favourite authority without any objection?"

Procedure

The PBL intervention: Timeline and Problem scenario

The intervention spanned a week, consisting of five 45-minute sessions.

Stage 1: Clarification of the problem and brainstorming

The day before the PBL model commenced, the EBI pretest was administered to all students. On the first day of the PBL instructional model, students were introduced to the structured problem scenario.

The problem scenario: "Imagine that the university Psychology department haS been selected by the Ministry of Electronics and Information Technology as an expert team from Madhya Pradesh to provide solutions to the unambiguous tensions regarding the reciprocal relationship between human life, AI, and ChatGPT. As an advisory panel of Psychologists, we will divide you into three different groups to explore what is known and what is yet to be known about the problem. Each group needs to develop a summary of their discussion, comprising the strongest and weakest solutions".

The researchers organized the students into three small groups of students, consisting of 8 to 10 members each. The researchers reminded them that they were required to participate in the group activities, as they represented an expert government panel tasked with providing the most beneficial solution to the assigned problem. Learning objectives were discussed. The researchers ensured that each student received a clear definition of the ill-structured problem and its associated concepts (artificial intelligence and ChatGPT).

During the initial introduction of the ill-structured problem, the researchers observed that the participants' baseline understanding of the assigned task could have been higher; only a few participants were initially aware of the problem at hand. Consequently, the researchers clarified the terms and notions used in the written description of the ill-structured problem. Specifically, the researchers explained what is meant by artificial intelligence and ChatGPT and provided a brief introduction to the current discussion regarding the pros and cons of the relationship between human beings and artificial intelligence.

Stage 2: Scaffolding and collaborative inquiry

One of the primary determinants of the success of PBL is its integration of teacher guidance during the learning process (De Grave et al., 1999; Hmelo-Silver & Barrows, 2008; Saye & Brush, 2002) Teacher-led, one-to-one scaffolding has been proven effective when students' initial understanding is low (van de Pol & Elbers, 2013). Hence, during the group discussions, the researchers intermittently provided one-to-one scaffolding to boost students' critical reflection on solving the problem. Clarifying students' understanding and repeatedly encouraging critical reflection are the main features of one-

to-one scaffolding (van de Pol et al., 2010). The researchers acted as facilitators rather than instructors.

All three groups received identical scaffolding to ensure internal validity. A standardised "epistemically reliable processes and ideals" sheets were provided by the researchers, which can motivate students to understand the importance of engaging in multiple perspectives while collecting evidence (Solomon, 2007);, pleasant emotions instead of negative emotions in knowledge-producing processes (Rinehart et al., 2014; Thagard, 2014); epistemic virtues like open-mindedness and patience in knowledge-producing processes (Zagzebski, 1996); and the impact of the echo-chamber effect while collecting knowledge from the internet (Inazu, 2018), while navigating the solutions for the proposed ill-structured problem.

Stage 3: Self-directed learning and research

Another major determinant of the success of PBL is the students' ability to engage in self-directed learning to comprehend the problem more deeply (Lohman & Finkelstein, 2000; Loyens et al., 2008). Employing sophisticated epistemological processes is essential for high-quality self-directed learning (Britt et al., 2014; Chinn et al., 2011; Richter & Schmid, 2010; Sandoval, 2003). ChatGPT was explicitly permitted during intervention sessions. However, the researchers instructed the participants to approach AI output as an "unverified source" that required triangulation with authentic databases like APA PsyNet.

Stage 4: Final presentation and defence

The students were given a week for individual learning on the ill-structured problem. They were asked to note what was known and what was yet to be known about the problem. After a week, the groups were asked to present their recommendations to the class. Each group prepared a 'position paper' and a 20-minute presentation arguing in favour of their stance. A cross-examination session by peers was also conducted. The researchers reviewed the strengths and weaknesses of the solutions and evidence offered by each group. The large group again discussed the best possible solutions, combining the optimal solutions derived from each small group.

Quantitative Data analysis and assumption testing

The study employed a paired-samples t-test to compare the mean scores of the pre-test and post-test on epistemological beliefs. The researchers found a paired-samples t-test to be most suitable for examining the hypothesis. The researchers verified essential statistical assumptions for the primary paired t-test analysis before running the analysis.

Normality of difference scores:

The normality assumption was examined using the Shapiro-Wilk test on the calculated difference scores *(Posttest-pretest).* The examination did not find significant deviation of the distribution from normality, $W = 0.94$, $p = .302$. Q-Q plot inspection ensured that difference scores were symmetrically distributed with no severe outliers. Cohen's d_z (formulated for a within-subjects design) was calculated with its corresponding 95% confidence interval to assess the magnitude of the intervention's effect.

Qualitative data analysis

Several prior studies have criticized the usage of self-report inventories for examining epistemic beliefs (DeBacker et al., 2008). Hence, the researchers administered retrospective semi-structured interviews to supplement the findings of the epistemic belief inventory, thus allowing the study to attain more corroborated data on the students' epistemic beliefs.

The qualitative data were analyzed using inductive thematic analysis. The following steps were involved in the process:

1. Familiarization with the transcripts
2. Generating initial codes
3. Reviewing and defining each theme

Member checking was performed by sharing summaries with the participants to enhance the accuracy of the transcripts. Furthermore, peer debriefing by an external researcher assisted in auditing the coding framework to eliminate researcher bias.

RESULTS OF STUDY

Quantitative findings

The current study confirmed the hypothesis. The results from the pre-test ($M = 115.70$, $SD = 14.70$) and post-test ($M = 67.90$, $SD = 9.50$) problem-based learning task indicate that the implementation of problem-based learning (PBL) resulted in an improvement in epistemological belief, $t(28) = 15.30$, $p<001$. Cohen's $d_z = 2.66$ The declining mean scores from pretest to posttest indicated a reduction in naive epistemological beliefs. Although the mean scores indicated a decline from pre-test to post-test, higher scores on the Epistemological Belief Inventory indicate more naïve epistemological beliefs. The findings confirming our hypotheses were consistent with literature that substantiates the effectiveness of the PBL model in fostering sophisticated epistemological belief (Belland et al., 2019; Liu & Zhu, 2018; Yadav et al., 2011).

PBL can motivate students to confront the "quick learning", "simple knowledge", and "omniscient authority" fallacies by making them struggle with the input data during the intervention that has no easy and direct answer. To the researchers' knowledge, no prior studies have found that exposure to the PBL model could significantly improve epistemological beliefs specifically among psychology undergraduates. The current study's findings align with literature that proves the effectiveness of self-regulated learning in fostering epistemic beliefs (Belland et al., 2019).

The findings can also be problematized against the relevant theoretical backgrounds. The EBI fundamentally considers dimensions such as engaging with tentative and complex knowledge, the sources of knowledge acquired, knowledge gained from interacting with others, and gradual learning as criteria for reaching sophisticated epistemological beliefs. Generally, the EBI measures general beliefs about knowledge and knowing. The current study's overall decline in EBI scores suggests that students might be interested in pursuing mastery goals and cognitive effort. If learners believe that knowledge does not come from authorities, but is instead actively constructed, they tend to focus inwardly on personal mastery. Conversely, learners who believe in the simplicity and certainty of knowledge are unlikely to exert cognitive effort in pursuing mastery goals. Likewise, if learners believe in the complex and tentative nature of knowledge, they may focus more on mastery goals (DeBacker &

Crowson, 2006). Despite the attempt to enhance the epistemological shift, a few students retained naive beliefs in dimensions such as 'omniscient authority', likely due to religious sentiments or prior traditional schooling.

Table 1. Paired-samples t-tests for individual EBI dimensions (N= 29)

EBI Subscale Dimension	Pretest, M (SD)	Posttest, M (SD)	Mean Difference
Certain Knowledge	25.80 (3.20)	12.60 (1.60)	-13.20
Simple Knowledge	22.20 (3.00)	10.00 (1.80)	-12.20
Omniscient Authority	21.30 (3.50)	13.60 (1.40)	-7.70
Quick Learning	25.60 (2.90)	17.50 (2.00)	-8.10
Innate Ability	20.80 (2.60)	14.20 (1.90)	-6.60
Total EBI Score	115.70 (14.70)	67.90 (9.50)	-47.80

Table 2. Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Prescore Epistemic Belief	115.70	29	14.70	2.70
	Postscore Epistemic Belief	67.90	29	9.50	1.70

Table 3. Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Prescore_epistemic_belief - postscore_epistemic_belief	47.70	16.80	3.10	41.40	54.10	15.30	28	.0

Qualitative findings

Several themes emerged from the qualitative investigation following the PBL intervention. The qualitative analysis revealed a clear distinction between students who demonstrated sophisticated epistemic cognition and those who maintained naive epistemic cognition.

Trajectories of sophisticated epistemic cognition

Certain knowledge

Each experimental group demonstrated divergent perceptions regarding the 'certainty' dimension of the knowledge production process. The following comment indicates that students realized the importance of evaluating different arguments regarding a topic, which may have been influenced by their exposure to "collaborative inquiry" and "exposure to multiple perspectives".

Student 2 (Group 1): I initially believed one could live happily in this technological world without concern. Previously, I had paid little attention to the technological challenges we discussed in the group last time. I now realize we must be careful when interacting with technology because each group member presented different arguments with robust evidence, either supporting, opposing, or presenting a balanced view on its usage.

Nine students shared similar views. Their responses were consistent with the "tentative knowledge" dimension described in Item 31 of the EBI: "Sometimes there are no right answers to life's big problems."

Some students also expressed the view that the researchers should have provided a visual representation illustrating how to navigate different knowledge sources–from the most authoritative to the least reliable–regarding the assigned problem. They shared this concern constructively, indicating that the students were curious to learn more and might have focused more on the PBL process if they had been given scaffolding, such as a graphical demonstration or a tutorial on sourcing information with representative examples. Evidence-based argumentation might have triggered curiosity among the students to learn more about ill-structured problems using graphical representations.

Student 3 (Group 2): I acquired significant insight into approaching a problem systematically. Could you provide a visual, graphic, or live demonstration on how to solve a similar ill-structured problem?

Epistemic virtues and positive epistemic emotions played pivotal roles in fostering a tentative understanding of knowledge processing among the students. These students demonstrated a view of the tentative nature of knowledge that was consistent with the 19th item of the EBI: "If two people are arguing about something, at least one of them must be wrong."

Student 6 (Group 1): I used to watch some televised discussions where some panel members would verbally abuse and blatantly oversimplify others' views. It made me disinterested in watching such time-wasting, verbal brawls. However, during the group discussion, everyone respected each other's views, and there was a harmonious flow between the arguments (smiling).

The following comment appears to indicate that students realized the importance of being exposed to multiple arguments and evidence-based argumentation,

which may have been influenced by the "collaborative inquiry" and "evidence-based argumentation" components.

Student 2 (Group 1): The respect and recognition group members gave made me think that multiple arguments could be correct. When someone presents their views with evidence without undermining their opponents' arguments, it creates the impression that we should receive those views with an open mind.

What was intriguing about these statements is that most of the students' "certain" approaches towards the nature of knowledge showed a shift toward the tentative dimension due to the strategies employed for the PBL intervention. These findings are consistent with the literature indicating that those who believe the nature of knowledge to be evolving (tentative) are better and more self-efficacious learners (Kizilgunes et al., 2009). However, some students remained inclined towards the certain nature of knowledge.

Student 4 (Group 2): Collaborating with others on any problem encountered is fine. However, there is only one argument more powerful than any other. I have heard many friends substantiate arguments in favour of and against the influence of ChatGPT on our lives. However, I believe ChatGPT will not be beneficial in any manner to our cognition.

The extant literature demonstrates a positive relationship between deep knowledge acquisition and the certainty of knowledge. Individuals who adopt deep-level acquisition strategies typically exhibit a desire to understand complex problems and are actively engaged in their studies (Jikamshi et al., 2016).

Simple knowledge

Seven students demonstrated a preference for the complex nature of knowledge. Students who subscribe to the belief that knowledge is complex may engage in a deep knowledge acquisition process, as previous literature has demonstrated a negative relationship between deep knowledge acquisition and the belief in simple knowledge (Jikamshi et al., 2016). The following comment from Student 5 (Group 2) may be influenced by the "scaffolding" PBL strategy as he stated he was unaware of the complex nature of the ill-structured problem and now understands the importance of digging deeper into expert opinions on any matter. The comment from Student 3 (Group 1) also may be indicative of the influence of "scaffolding" as he understands the existence of problems associated with AI that require meaningful cognitive effort.

Student 5 (Group 2): I was unaware of many complex expert opinions regarding this ill-structured problem. We psychology students must dig deeper to understand the complexities and challenges artificial intelligence may bring to human lives.

Student 3 (Group 1): The problem chosen for the group discussion suggested there were problems requiring meaningful cognitive effort to generate solutions.

Student 1 (Group 1): I feel reproachable as a psychology student that my understanding of the solution to this problem is non-existent. We need brainstorming like this to remain updated on the real issues happening in the world.

Some students favoured the simple nature of knowledge.

Student 6 (Group 2): The researchers should have provided solutions to this problem. Why should we spend so much time searching for the answer?

Student 7 (Group 2): No one is interested in spending so much time reading to find a solution to the current problem. A solution to the harmful effects of artificial intelligence is available on the internet itself [laughs].

The large-scale availability of Google Search and ChatGPT functionality has convinced people that there is no need to consult multiple sources to find solutions, as knowledge is available just a click away on the internet. If someone adopts a simplistic epistemic approach, they are less likely to consider complex solutions to moral dilemmas or may try to represent the problem in an overly simplistic manner (Bendixen et al., 1998).

Quick learning

Five students supported a quick learning approach to knowledge. The following comment from a student may be influenced by the "collaborative inquiry" strategy used in the PBL approach, which stimulated his belief in the importance of patient and extended constructive discussions regarding scientific investigations.

Student 5 (Group 2): We need rigorous scientific investigations into this problem because artificial intelligence is becoming a fundamental part of our daily lives. Patience and extended, constructive discussions like ours can yield sustainable solutions to the problem.

The following comment from a student may be influenced by the "reflection on sources of knowledge" PBL approach, as he emphasizes the importance of reflecting on the acquired knowledge.

Student 5 (Group 1): It is concerning that students copy information from ChatGPT for their assignments and projects without reflecting on the knowledge. It is a problematic situation that many people do not feel guilt regarding, and they praise the internet for making their tasks highly manageable.

Omniscient authority

Seven students favoured the idea that knowledge must be acquired from sources other than authoritative figures.

Student 3 (Group 2): I appreciate the researchers' effort in conducting a discussion of this nature. More insightful knowledge emerges only when multiple individuals with different expertise pool their learning through interaction in group discussions.

Student 6 (Group 1): It is worrying that many people believe tech giants, like Elon Musk, will exclusively engage in beneficial activities when implementing artificial intelligence in our lives.

We can infer from the findings that students who engage in sophisticated means, such as rationality, to justify their knowledge can shift toward more sophisticated epistemic beliefs (Hofer & Pintrich, 1997; Schommer, 1990). The findings also disrupt the belief in "omniscient authority" (the belief that a specific set of beliefs or a specific person is always right) by recognising the importance of peer-to-peer validation. Such a belief may have emerged from the mechanism of "collaborative inquiry" used in PBL.

Innate ability

Twelve students believed that intelligence could be improved during knowledge processing. Such a belief may have emerged through the self-directed learning approach used in PBL, which challenges the belief in "innate ability" by rewarding effort over "quick learning".

Participant Student 3 (Group 2): The assigned problem stimulated me to engage in reading and watching different sources. I am not a studious reader. However, I wanted to

read more trustworthy sources to present my ideas in the group discussion. The thought that I had to deliver an excellent presentation helped me to read smoothly. Even though I am not an avid reader, I read a lot, and it increased my knowledge.

Participant Student 3 (Group 1): The self-learning process and the researchers' encouragement motivated me to read more. I cannot believe I could collect so much information on the problem; I used to think I was not a brilliant kid who could manage reading (laughs).

Trajectories of retained epistemic cognition

Certain knowledge

Some students remained inclined toward the notion of a certain nature of knowledge.

Participant Student 4 (Group 2): Collaborating with others on any problem encountered is fine. However, there is only one argument that is more powerful than any other. I have heard many friends substantiate arguments in favour of and against the influence of ChatGPT on our lives. However, I believe ChatGPT will not be beneficial in any manner to our cognition.

Extant literature demonstrates a positive relationship between deep knowledge acquisition and the certainty of knowledge. Individuals who adopt deep-level acquisition strategies typically exhibit a desire to understand complex problems and are actively engaged in their studies (Jikamshi et al., 2016).

Simple knowledge

Some students favoured the simple nature of knowledge.

Participant Student 6 (Group 2): The researchers should have provided solutions to this problem. Why should we spend so much time searching for the answer?

Participant Student 7 (Group 2): No one is interested in spending so much time reading to find a solution to the current problem. A solution to the harmful effects of artificial intelligence is available on the internet itself [laughs].

The large-scale availability of Google Search and ChatGPT functionality has convinced people that there is no need to consult multiple sources to find solutions, as knowledge is available just a click away on the internet. If someone adopts a simplistic epistemic approach, they are less likely to consider complex solutions to moral dilemmas or may try to represent the problem in a simpler manner (Bendixen et al., 1998b).

Quick learning

Five students supported the quick learning approach to knowledge.

Participant Student 2 (Group 2): It is a waste of time discussing this topic. Let people who favor the technology do it; let people who are against it keep their beliefs. We cannot find a solution where everyone agrees in unison.

Participant Student 3 (Group 1): Why must we conduct long discussions on this issue? We are in a postmodern world; we may get stuck on particular issues if we do not act fast. Let us try to find a solution quickly.

Research shows that a belief in quick learning negatively affects deep knowledge processing and yields lower GPA scores (Jikamshi et al., 2016; Schommer, 1993).

Omniscient authority

Some students opined in favour of an omniscient authority.

Participant Student 3 (Group 2): Searching through different sources and discussing topics like this with a peer group is futile. A more trustworthy solution can be found if we consult senior psychologists with years of experience.

Participant Student 6 (Group 1): Whatever the issue, our (mentioning a national political leader) will solve the problem. Why do we need to induce headaches by thinking about the solution?

Research suggests that students who believe knowledge is transferred from authority are frequently more self-efficacious in learning (Kizilgunes et al., 2009; Rasheed S M et al., 2026). There is also a tradition of using authority figures as a justifiable source in philosophical epistemology (Murphy et al., 2007).

The driving pathways of an epistemic shift within PBL

The significant improvement in epistemological beliefs across the EBI dimensions may be caused by the structural architecture of the mechanisms used in the PBL intervention. Two pathways of PBL disrupt the traditional didactic instruction, which emphasizes naive dimensions of the EBIs —such as omniscient authority (teacher or a textbook as absolute truth) and certain knowledge —by dismantling the dependency on a single, authoritative figure or source.

1. Socio-cognitive conflict

Compelling students to actively engage in collaborative group brainstorming to solve real-world dilemmas, like the ill-structured problem in our study can stimulate a socio-cognitive conflict. This requires students to address divergent perspectives, thus questioning the inadvertent attribution of the locus of validation to a single authoritative source or to quick, simple learning.

2. Experiential failure of AI as authority

Scaffolding students' understanding regarding the inherent algorithmic limitations of generative AI models like ChatGPT with "epistemically reliable processes and ideals sheets" may disrupt the belief of students' belief in generative AI as an absolute truth.

Understanding epistemic resistance

The relative stability of some dimensions of the EBI among a few students underscores the limitations of short-term pedagogical PBL interventions. For students embedded in an exam-driven, traditional academic system for many years, approaching knowledge processing as quick, simple, and innate serves as a protective psychological shield. However, they might have already developed a high tolerance for cognitive load whenever faced with complex labour-intensive tasks like addressing an ill-structured problem. Consequently, this cognitive rigidity triggers a "rebound effect", where they revert to naive dimensions of epistemological beliefs as an anxiety-reduction strategy.

IMPLICATIONS

There is a need for future discussions to address the contradictory literature on the roles of epistemic belief dimensions in fostering sophisticated epistemology. In

other words, as the current study suggests, the literature shows that students involved in certain vs. tentative or omniscient authority vs. personal justification interactions with others could employ tools that foster sophisticated epistemological beliefs.

Psychology is fundamentally the scientific study of probabilistic human behavior, requiring those studying it to possess highly sophisticated epistemic cognition to navigate large language models and AI. Psychologists must therefore cultivate a learning ecosystem where they guide students to achieve AI literacy and epistemic vigilance. Students should not be restricted from utilizing the beneficial output of AI; rather, AI needs to be integrated as an authentic learning context. Educators can train students on the mechanisms by which AI algorithms work, emphasizing the need to double-check and cross-verify the information by doing epistemic reflection and source evaluation.

LIMITATIONS

Sampling and design constraints

There may be issues in generalizing the findings from the current study across different cultural and institutional contexts or among more diverse students because the study utilized a comparatively small sample size (N= 29) drawn from a single institution via convenience sampling. Furthermore, the absence of a control group and the lack of randomization in participant selection in the current one-group pretest-posttest design prevent us from solely attributing the observed changes in epistemic cognition to the PBL intervention. Consequently, it is difficult to eliminate external confounding variables like concurrent academic work or natural maturation effects, over a one-week period.

Testing effects and measurement modality

It is also difficult to rule out the testing effect due to the administration of the EBI scale twice withing a short. One-week window. Participants may have developed a heightened awareness of the current study's underlying objectives, leading them to artificially generate more sophisticated posttest responses. Additionally, we relied entirely on self-report measures during the quantitative phase, which explore participants' perceived beliefs rather than real-time epistemic behaviour during problem-solving tasks.

Social Desirability and Facilitator Bias

Social desirability bias might have influenced the responses given by the students during the qualitative follow-up interviews. This could be particularly pronounced given potential facilitator bias, as the researchers acted as facilitators during the PBL intervention sessions. This dynamic may have created a subtle demand characteristic, steering students towards giving responses that matched the researchers' expectations.

Temporal Boundaries

Finally, the study lacks longitudinal tracking of the long-term influence of the PBL intervention. Hence, the lack of a longitudinal follow-up assessment makes it difficult to predict the sustainability of the observed epistemic change. We cannot definitively attribute the reduction in naive epistemic beliefs to a permanent restructuring of the students' epistemic cognition, nor can rule out that the reduction is merely a temporary epistemic sophistication that may fade once they return to their conventional learning environment. To mitigate some of these limitations, the researchers attempted to control for extraneous variables that could intervene in the research setting by following a standardised PBL script.

DECLARATION

Ethics approval and consent to participate

The study was approved by the Ethics Committee of the Department of Psychology, Indira Gandhi National Tribal University, Amarkantak, 4848787, Madhya Pradesh, India.

Consent for publication

I hereby give my complete consent for this research to be published for scholarly purposes, and I'm prepared to offer any assistance or more details that are required to make the publication process go more smoothly.

Availability of data and materials

The study data may be made available on a genuine demand from the corresponding author.

Conflicts of interest statement

The authors declared no conflict of interest.

Funding

The authors have no funding to report.

Artificial Intelligence-Assisted Technology

Artificial Intelligence tools were used to assist language refinement, proofreading and formatting under the direct supervision of the authors. The authors take full responsibility for the accuracy, authenticity, and integrity of the final manuscript content.

Authors' contributions

Each author made an equal contribution to the study's design, data collection, data analysis, and the creation of the manuscript's preliminary and final versions.

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ADDITIONAL INFORMATION

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