

Impact of Concept Mapping on Reflective Thinking among Secondary School Students: Evidence from Bihar, India

Dauli Kumari^{1*}

ABSTRACT

This study examines the effect of concept mapping on secondary school students' reflective thinking, highlighting the cognitive processes involved in meaningful learning. Using a quantitative research design, primary data were collected from 105 secondary school students enrolled in government and private schools in the East Champaran district of Bihar, India. Students' concept-mapping ability and reflective thinking were measured using a structured, standardised questionnaire. The data were analysed via regression techniques to examine the relationship between concept mapping and reflective thinking, as well as differences by gender and school type. The findings reveal a statistically significant positive association between concept mapping and reflective thinking, indicating that higher levels of concept mapping ability are associated with stronger reflective thinking skills. No significant gender differences were observed in reflective thinking outcomes. However, a significant difference was found between school types, with students from private schools demonstrating higher levels of reflective thinking than those from government schools. The results suggest that concept mapping is an effective pedagogical strategy for promoting reflective thinking among secondary school students. The study highlights the importance of reflective teaching practices, particularly in government schools, to reduce disparities in higher-order thinking skills. These findings have important implications for teachers, curriculum planners, and education policymakers seeking to strengthen reflective learning and classroom instruction at the secondary level.

Keywords: *Concept Mapping, Reflective Thinking, Cognition*

Learning is a complex mental process that helps students develop skills such as reasoning, analysis, reflection, and problem solving. In schools, students do not just memorise information; they actively try to understand what they learn by forming ideas, seeing how things are connected, and using logic to solve problems. Among these skills, reflective thinking is especially important because it helps students think about what they know, question their assumptions, and link new learning with their past experiences. The mastery of reflective and critical thinking is essential for meaningful learning and academic development. Reflective thinking helps students move beyond memorising facts and think more deeply about their learning. Research shows that teaching tools such as concept mapping and blogging support reflective thinking by helping students organise

¹PhD, Research Scholar, Jawaharlal Nehru University, New Delhi.

*Corresponding Author

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ideas, review their understanding, and make sense of their learning experiences (Xie & Sharma, 2011). Concept mapping is a visual learning strategy that graphically represents knowledge by illustrating the relationships between concepts. Concepts are enclosed in boxes or circles and connected by labelled lines that indicate relationships. In concept mapping, a **concept–link–concept** structure forms a *proposition* that is a meaningful statement about an object or event. These links, also called *units of meaning*, show how ideas are connected to build understanding (Canas et al., 2003). By making thinking visible, concept maps help learners organise information and see how concepts are related. Creating a concept map also involves mental processes linked to memory. When students create a concept map, ideas stored in long-term memory are brought back, rearranged, and connected by working memory. Their attention, past knowledge, and problem-solving ability shape how they choose and link ideas. When students take part actively in this process, learning becomes meaningful and can lead to creative and higher-level thinking. The idea of concept mapping is based on Ausubel's theory of meaningful learning. Novak and Gowin (1984) argued that meaningful learning occurs when three conditions are met: (1) the availability of relevant prior knowledge, (2) the presentation of meaningful learning material, and (3) the learner's conscious decision to learn meaningfully. Concept maps work as teaching tools that help teachers create these conditions by encouraging students to link new information with what they already know. When this happens, learning becomes meaningful and supports reflective and creative thinking. From an educational point of view, reflective thinking means carefully and systematically examining one's own thinking. It involves questioning ideas, checking beliefs, considering different options, and making reasoned decisions. Critical thinking is often seen as a form of reflective practice that helps learners make clear and logical links between their assumptions, evidence, and well-reasoned conclusions (Moafian & Ghanizadeh, 2012). Scriven and Paul (2004), as cited in Khodadady & Ghanizadeh, (2011), further described critical thinking as a process in which individuals improve the quality of their thinking by consciously regulating their reasoning and applying intellectual standards. This definition shows that reflective thinking has a metacognitive side, where learners consciously watch and judge their own thinking. Similarly, Paul (1990, as cited in Ghanizadeh, 2017) described critical thinking as self-directed and disciplined thinking that involves good-quality reasoning in a given area. The American Philosophical Association defines critical thinking as purposeful and self-controlled judgment that involves interpreting, analysing, evaluating, and drawing conclusions on the basis of strong ideas and evidence. Together, these definitions highlight reflection, self-regulation, and evaluation as key parts of higher-level thinking. Given the strong theoretical alignment between concept mapping and reflective thinking, it is important to empirically examine how concept mapping influences reflective thinking among secondary school students. Although many studies have examined concept mapping in relation to academic achievement and critical thinking, very few have focused directly on reflective thinking at the secondary school level, especially across different school settings. To address this gap, the present study examines how concept mapping affects the reflective thinking of secondary school students in the East Champaran district of Bihar, with special attention to differences by gender and type of school.

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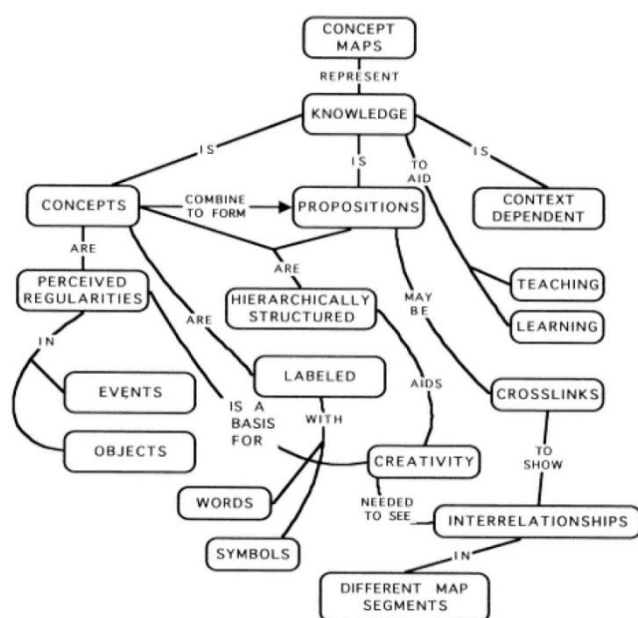


Figure 1 A concept map depicting the key ideas and principles through which an effective concept map was developed, which was created by Novak. 1998

The concept mapping process involves many aspects, such as human knowledge creation, which is based on the constructivism approach, which integrates thinking, feeling, and acting, and the cognitive process of assimilation is also involved in meaningful learning through which reflective thinking is generated to solve complex things and creative work.

LITERATURE REVIEW: CONCEPT MAPPING AND REFLECTIVE THINKING

Concept mapping is widely used as a teaching strategy to support meaningful learning and higher-level thinking. It is based on Ausubel's theory of meaningful learning, which stresses the importance of linking new knowledge with what learners already know (Rao et al., 2002). From a constructivist point of view, concept mapping helps students actively organise ideas, see relationships, and build understanding instead of just memorising information. Researchers suggest that concept mapping can develop higher-level thinking skills such as analysis, synthesis, critical thinking, and reflective thinking (Canas et al., 2017). By requiring learners to justify links between concepts, concept maps encourage reflection, self-monitoring, and deeper cognitive engagement. However, direct research on the impact of concept mapping on reflective thinking is limited, especially at the secondary level. Blackwell et al. (2008) reported that concept mapping helped preservice teachers make reflective decisions, revealing its value for reflective practice. More direct evidence comes from Sieben et al. (2020), who reported that 82% of students' reflective concept maps showed deep, critique-level reflection. More direct evidence was provided by Sieben et al. (2020), who reported that 82% of students' reflective concept maps reached a critique-level depth of reflection. Despite these findings, such studies are rare and often do not focus on secondary school students, and a larger body of research shows that concept mapping is effective in developing related cognitive skills among secondary school students. Studies have reported significant improvements in higher-order cognitive processes such as applying, analysing, evaluating, and creating knowledge (Bera et al., 2016; Bramwell-Lalor et al., 2014). Similar positive effects have been reported across subjects, including biology, chemistry, mathematics, and physics (Awofala et al., 2010; Osman et al., 2013; Pankratius et

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al., 1990). These skills are closely linked to reflective thinking, and research on critical thinking supports the potential of concept mapping. Khodadady and Ghanizadeh (2011) and several studies in professional education contexts have shown that concept mapping significantly improves learners' critical thinking ability. Although critical thinking is not identical to reflective thinking, it involves evaluation, judgment, and self-regulation. Overall, the literature suggests that concept mapping has strong potential to support reflective thinking. However, there is a clear gap in the research that directly examines its impact on reflective thinking among secondary school students. This gap highlights the need for focused empirical studies in school contexts to better understand how concept mapping can be used to develop reflective thinking.

Associations between concept mapping and reflective thinking:

According to Bruner's concept attainment model, concept mapping is a mental representation, and the elements of concept mapping, such as focus, syntax, and social systems, must be built for any concept. However, these elements germinate through cognitive activation. There are multiple structures and processes of cognition in the human brain and, accordingly, events or problems related to its function. We have many cognitive structures that can be applied to new stimulus inputs (Sedikides, C & Skowronski, J. J., 1991). There is also a need to activate our cognitive structure according to the problem's demand. There are three cognitive structures given by Garner (2007): Comparative thinking structures process information by identifying how bits of data are alike and different. These include recognition, memorisation, conservation of constancies, classification, spatial orientation, temporal orientation, and metaphorical thinking. Second, symbolic representation structures change information into forms that people understand and accept. These are the shared ways of expressing meaning. These include spoken and body language, numbers and mathematics, music and rhythm, movement, dance, and gestures. They also involve how people interact with each other, as well as visual forms, such as drawings, paintings, symbols, and logos. In addition, they include physical forms such as sculpture and construction and expressive forms such as role-play, drama, simulations, and multimedia. Third, logical reasoning structures use abstract thinking to process and create information in a systematic way. These include deductive and inductive reasoning, thinking through examples and possibilities, understanding cause-effect relationships, analysing and combining ideas, evaluating information, framing problems, and solving them. Concept mapping is a mental representation of an object and is largely dependent on cognitive structure. According to information processing theory, students take information and store it in their short, long-term memory, which is based on the similarity/dissimilarity of the new object with prior knowledge. This is how a person classifies a thing that is called assimilation, according to Piaget's theory. Therefore, prior knowledge, which is often termed experience and learning from experience, plays a role in the transfer of learning theory (Steiner, G., 2001). Reflection is considered a type of learning (Leitch, R & Day, C., 2001) and. Concept mapping is a teaching strategy for developing critical thinking skills (Nirmala, T & Shakuntala, B. S., 2011). The association between concept mapping and reflective thinking or critical thinking is deepened in the concept mapping structure, such as chain (linear structure in which the concept is linked logically), spoke (single-level radial structure in which all relevant aspects of a topic are linked directly to the concept), and network (highly integrated and hierarchical structure), which is generated by the abovementioned cognition and on the basis of which one can perform is one's critical thinking or ability to articulate facts or solve any problem. Although concept mapping and

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reflective thinking are performed inside the brain, they have their own limitations and are not easy to illustrate.

Objective:

1. To study the influence of concept mapping on the reflective thinking of secondary-level students in the East Champaran District of Bihar.
2. To study the impact of concept mapping on the reflective thinking of secondary school students irrespective of gender and school type in the East Champaran District of Bihar.

Hypotheses:

1. **H01:** There is no significant impact of secondary students' concept mapping on their reflective thinking in the East Champaran District of Bihar.
2. **H02:** There was no significant difference between the govt. Secondary school students' concept mapping of reflective thinking in the East Champaran District of Bihar.
3. **H03:** There is no significant impact between male and female students' concept mapping on their reflective thinking in the East Champaran District of Bihar.

METHODOLOGY

This study used a quantitative research design with a descriptive survey method to examine how concept mapping affects reflective thinking among secondary school students. This approach was suitable for studying the relationships between variables and testing the research hypotheses. The study included students from the government and private secondary schools in the East Champaran district of Bihar. The participants were selected via a random sampling method. The final sample consisted of 105 secondary school students drawn from ten schools, including five governments and five private institutions. Data were collected via a self-developed and standardised questionnaire aligned with the objectives of the study. The questionnaire consisted of two sections. The first section contained fill-in-the-blank questions to assess students' concept-mapping ability. The second section included reflective, open-ended questions to measure students' reflective thinking. The responses were analysed via suitable statistical methods to examine the relationship between concept mapping and reflective thinking and to identify differences based on gender and type of school.

Theoretical Framework and Model Specification

To analyse the data, the renowned statistical software package SPSS was used to run the two regression models, that is, a simple two-variable regression model for H_{0.1} and a dummy variable regression model for H_{0.2} and H_{0.3}. This is explained as follows.

$$Y_i = \beta_1 + \beta_2 X_i + u_i \quad (\text{equ. 1})$$

where Y_i is the dependent variable (reflective thinking), β_1 is the intercept, β_2 is the slope coefficient, X_i is the explanatory or regressor variable (concept mapping), and u_i is the error term or another stochastic variable that is not included in the model.

$$Y_i = \beta_1 + \beta_2 D_{2i} + \beta_3 D_{3i} + u_i \quad (\text{equ. 2})$$

This is an ANOVA model of two qualitative variables. where Y = reflective thinking, D_2 = gender status, 1= male, 0= otherwise, D_3 = school type, and 1= Govt. School, 0= otherwise, β_1 = benchmark category for female private secondary school students.

RESULTS AND DISCUSSION

Objective 1: Influence of concept mapping on reflective thinking

The first objective of this study was to examine the influence of concept mapping on secondary school students’ reflective thinking. The results of the simple linear regression analysis are presented below:

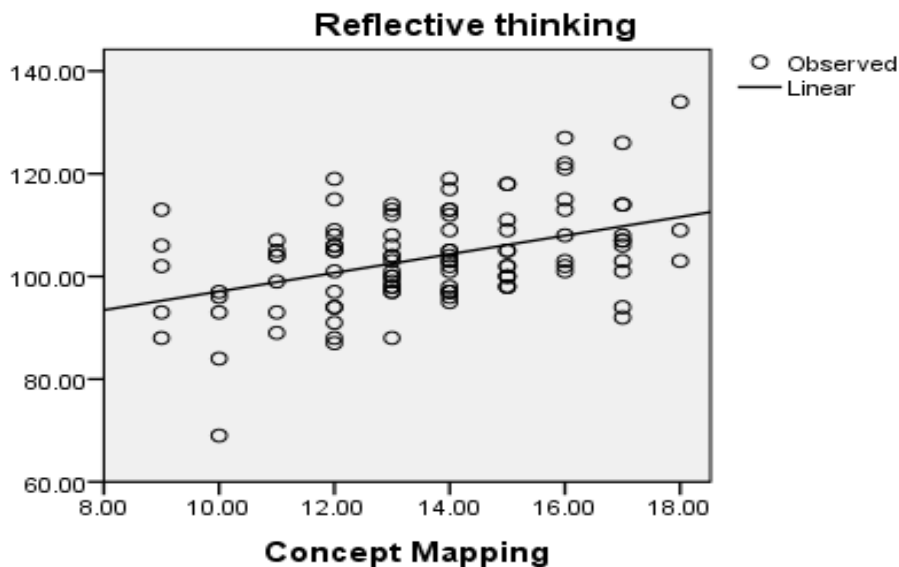


Fig:2 Influence of concept mapping on reflective thinking:

This regression line of concept mapping on reflective thinking in secondary-level students is positively related, as concept mapping increases reflective thinking, and its score is scattered.

Model Summary									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.423 ^a	.179	.171	8.80231	.179	22.475	1	103	.000

a. Predictors: (Constant), Concept Mapping

The correlation coefficient between concept mapping and reflective thinking is 0.423, indicating a moderately positive relationship between the two variables. The R square value of 0.179 shows that 17.9% of the variation in the reflective thinking scores can be explained by the students’ concept mapping scores. The standard error of the estimate (8.80) represents the average dispersion of the observed reflective thinking scores around the regression line. The adjusted R square value of 0.171 indicates that approximately 17.1% of the variance in reflective thinking (the dependent variable) is explained by concept mapping (the independent variable) after adjusting for sample size.

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ANOVA^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	1741.340	1	1741.340	22.475	.000 ^b
	Residual	7980.507	103	77.481		
	Total	9721.848	104			

a. Dependent Variable: Reflective thinking

b. Predictors: (Constant), Concept Mapping

The Anova table is showing that the F value is 22.47 and the p value is .000 which is indicating that this regression model is significant.

Coefficients^a								
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error	Beta			Lower Bound	Upper Bound
1	(Constant)	78.942	5.294		14.913	.000	68.443	89.440
	Concept Mapping	1.813	.382	.423	4.741	.000	1.055	2.572

a. Dependent Variable: Reflective thinking

On the basis of the regression results, each point on the regression line represents the expected (mean) value of reflective thinking (Y) for a given value of concept mapping (X). The estimated slope value ($\beta_2 = 1.813$) shows that concept mapping has a positive effect on reflective thinking. Simply put, when a student's concept mapping score increases by one unit, their reflective thinking score increases by approximately 1.81 units within the sample. The intercept ($\beta_1 = 78.942$) shows the expected level of reflective thinking when the concept mapping score is zero. Although a score of zero may not have practical meaning, the intercept serves as a baseline for the regression equation, and the t test value for the slope coefficient ($t = 4.741$, $p < .001$) indicates that the effect of concept mapping on reflective thinking is statistically significant. This result confirms that concept mapping is a meaningful predictor of reflective thinking among secondary school students. Therefore, the null hypothesis H01, which states that concept mapping has no significant effect on reflective thinking, is rejected.

2.Obj. To study the impression of concept mapping on the reflective thinking of secondary students, irrespective of gender and school type. To analyse this second objective, *two qualitative dummy variable ANOVA models* were used.

Model Summary^b				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.378 ^a	.143	.101	10.46553

a. Predictors: (Constant), School Type, gender

b. Dependent Variable: Reflective thinking

ANOVA^a						
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	747.380	2	373.690	3.412	.043 ^b
	Residual	4490.620	41	109.527		
	Total	5238.000	43			

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a. Dependent Variable: Reflective thinking

b. Predictors: (Constant), School Type, gender

The Anova table is showing that the F value is 3.41 and the p value is .043 which is indicating that this regression model is significant.

Coefficients

Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	95.0% Confidence Interval for B	
		B	Std. Error				Lower Bound	Upper Bound
1	(Constant)	70.863	12.480		5.678	.000	45.659	96.066
	gender	.849	.647	.191	1.312	.197	-.458	2.156
	School Type	1.556	.749	.303	2.078	.044	.044	3.068

a. Dependent Variable: Reflective thinking

RESULTS AND DISCUSSION: DUMMY VARIABLE REGRESSION (H02 & H03)

The dummy variable regression model looks at differences in reflective thinking by gender and type of school, with female students from private secondary schools used as the reference group. The intercept value ($\beta_1 = 70.863$) represents the average reflective thinking score for this group. The coefficient for male students ($\beta_2 = 0.849$) suggests that male students score approximately 0.85 points higher in reflective thinking than female students from private schools do. This gives an estimated average score of 71.71 for male students. However, the t value ($t = 1.312, p = .197$) shows that this difference is not statistically significant at the 5% level, meaning that it is not strong enough to be considered meaningful. This finding indicates that reflective thinking did not differ significantly between male and female students. Therefore, H03, which states that there is no significant impact of gender on the relationship between concept mapping and reflective thinking, is accepted. The coefficient for government school students ($\beta_3 = -1.556$) indicates that students from government secondary schools score, on average, 1.556 units lower in reflective thinking than do students from private secondary schools. This results in an estimated mean reflective thinking score of 69.31 for government school students. The difference between the government and private school students was statistically significant, as indicated by the t value ($t = 2.078, p = .044$). This result confirms that the type of school has a significant effect on reflective thinking. Therefore, the null hypothesis (H02), which states that school type has no significant effect on reflective thinking, is rejected. The findings show that reflective thinking does not differ by gender but does differ clearly by school type. This points to differences in teaching and learning environments between government and private secondary schools.

Findings

1. Concept mapping had a significant positive influence on reflective thinking among secondary school students in the East Champaran District of Bihar. A one-unit increase in the concept mapping score leads to an average increase of 1.81 units in reflective thinking.
2. The effect of concept mapping on reflective thinking was similar for both male and female students. When using concept
3. In terms of mapping, boys and girls showed almost the same level of reflective thinking.

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4. However, the effect clearly **differed** by school type. Students from private secondary schools presented higher levels of reflective thinking than students from government secondary schools did.

DISCUSSION

This study investigated how concept mapping affects reflective thinking among secondary school students in the East Champaran district of Bihar. The results revealed a clear positive link between the two. Students who were good at concept mapping also showed stronger reflective thinking. This finding supports learning theories, which say that learning becomes meaningful when students connect new ideas with what they already know (Ausubel, 1963; Novak & Gowin, 1984). Concept mapping asks students to organise ideas, see how concepts are connected, and explain these links. These actions closely match key parts of reflective thinking, such as analysing, evaluating, and combining ideas. Therefore, the structure of concept maps naturally supports reflective thinking by guiding students' thought processes (Cañas et al., 2003). The size of the regression value ($\beta = 1.813$) suggests that even small improvements in students' concept-mapping skills can lead to noticeable gains in reflective thinking. This fits with the idea that reflective thinking develops when higher-level mental skills such as classifying, comparing, using symbols, and logical reasoning are activated, all of which are supported by concept mapping (Garner, 2007). Reflective thinking is also closely connected to metacognitive skills, especially the ability to observe, evaluate, and control one's own thinking (Moafian & Ghanizadeh, 2012). Concept maps offer learners visual and external representations of their understanding, allowing them to examine the coherence, completeness, and accuracy of their ideas. Through this process, learners become more aware of their own thinking, strengthening their reflective capacity. This study revealed no statistically significant difference between male and female students in the relationship between concept mapping and reflective thinking. This suggests that reflective thinking is not inherently shaped by gender but rather by the learning opportunities and instructional practices to which students are exposed. This finding supports earlier research showing that when students receive proper support and effective teaching, boys and girls develop cognitive and reflective skills in similar ways (Ghanizadeh, 2017). The lack of gender differences suggests that reflective thinking is a skill that can be developed in all students. In contrast, a clear difference was observed between students from government and private secondary schools, with private school students showing higher levels of reflective thinking. This difference may be due to variations in teaching quality, the classroom environment, teaching methods, or access to learning resources. Earlier studies have shown that reflective learning is strongly influenced by the conditions under which teaching and learning occur (Leitch & Day, 2001). This finding also matches national evidence, such as that of ASER (2019), which points to ongoing learning gaps between the government and private schools in India. Together, these results suggest that concept mapping not only is a teaching tool but also reflects the wider learning environment created in classrooms. Differences in students' reflective thinking are likely to appear when teaching support, teacher involvement, and learning resources differ across schools. From a constructivist view, reflective thinking grows when students are encouraged to make connections, question ideas, and think about other viewpoints processes that are central to concept mapping (Xie & Sharma, 2011). Overall, the findings highlight the need to improve teacher training, classroom practices, and teaching methods, especially in government schools. Improving the quality of teaching and encouraging reflective teaching approaches are important to ensure that all students, regardless of the type of school they attend, have equal chances of developing reflective and higher-level thinking skills.

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Implications of the Study:

1. This study provides evidence that concept mapping and reflective thinking are highly valuable for meaningful learning. Therefore, it is necessary to draw the attention of education stakeholders to reflect on it and minimise the learning crisis (ASER report 2019 shows that India's learning crisis is continuing).
2. Concept mapping has been used in classroom teaching (Holcombe. M & Shonka. A, 1993). Reflective thinking indicates students' mastery of content. Indeed, it has a significant effect on effective teaching and learning.
3. It is necessary to assess the variation in classroom teaching that explains why students in private schools have better higher-order thinking than those in government schools do. This situation creates a greater demand for high-quality school education.

CONCLUSION

This study examined the influence of concept mapping on the reflective thinking of secondary school students in the East Champaran district of Bihar. These findings clearly show that concept mapping has a strong and positive effect on students' reflective thinking. Students who were good at creating and organising concept maps also showed higher levels of reflective thinking, which points to deeper engagement with learning. This finding supports meaningful learning and constructivist theories, which state that learning becomes meaningful when students actively connect new ideas with what they already know (Ausubel, 1963; Novak & Gowin, 1984). Concept mapping offers a clear structure that helps students organise ideas, see connections, and reflect on their understanding. As suggested in the literature, such processes naturally promote reflective thinking by encouraging analysis, synthesis, and self-evaluation (Canas et al., 2003; Xie & Sharma, 2011). Adolescence is a critical stage of cognitive development during which students actively construct concepts and test ideas through exploration and reflection. The present findings show that concept mapping supports this learning process by helping students use their developing thinking skills in meaningful and creative ways. By using concept maps repeatedly, students improved their thinking, better understood how ideas are connected, and strengthened their reflective skills. No clear difference was found between boys and girls, which suggests that reflective thinking can develop equally when students are given proper learning opportunities. However, a clear difference was observed between government and private school students. This finding shows that the type of school plays an important role in shaping reflective thinking. The gap between government and private schools may be due to differences in teaching quality, classroom practices, access to learning resources, and academic support. This conclusion matches earlier research and national assessments that point to differences in learning environments across school types. Concept mapping is not just a teaching method; it also reflects the wider school environment in which students learn. The study confirms that concept mapping is an effective way to develop reflective thinking among secondary school students. However, how well it works depends on the quality of teaching, classroom practices, and school support. The findings show a clear need to improve teacher training, promote reflective teaching methods, and strengthen classroom practices, especially in government schools, so that all students have equal opportunities to develop reflective and higher-level thinking skills. Future research should further explore the longitudinal effects of concept mapping and investigate how instructional interventions can reduce school-based disparities in reflective learning outcomes.

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Conflict of Interest

The author(s) declared no conflict of interest.

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