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Moving Beyond Cognition: An Exploration into the Metacognitive Awareness of Science Teachers on STEM Education

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ABSTRACT

Science, technology, engineering, and mathematics (STEM) education has gained popularity as an interdisciplinary approach that combines these subjects into a single curriculum. STEM concepts align with the competencies the contemporary workforce requires, making it a desirable education model to foster twenty-first-century skills. The dynamism of the metacognitive awareness of science teachers in STEM has not been the subject of serious research. This study explores the metacognitive awareness level of science teachers in STEM, and the results are average. A gap exists between the living culture and the learning culture of students in this digital era. STEM is a new way of learning and comprehending in terms of a sustainable future.

Keywords: Metacognitive awareness, Science teachers, STEM, STEM education, Sustainable future, Teacher Education, Twenty-first-century skills

INTRODUCTION

The design of educational systems has been reexamined by educational specialists around the world (Beach et al., 2014). Science, technology, engineering, and mathematics (STEM) integration has become increasingly important in the rapidly changing educational landscape. A comprehensive approach to education, STEM education, encourages students to investigate real-world issues, participate in cross-disciplinary thinking, and build various skills necessary for success in the twenty-first century (Brown, 2012). To encourage students to study and to better comprehend and address real-world challenges, it is essential to advance an integrated approach to STEM education that incorporates real-life scenarios (English, 2016). Although STEM education is now widely recognized, there are opportunities and problems when it is implemented in the Indian education system.

The contribution made by science teachers, who serve as catalysts in molding students' perspectives and perceptions, interests, and STEM-related competencies, is an essential component of STEM education in India. To ensure the progress of STEM teaching, it is pivotal to understand the awareness, attitudes, and metacognitive processes of Indian science teachers and how they perceive the intellectual process and pathway involved in this process. To shed light on their attitudes, knowledge gaps, and areas needing professional development, this investigation aims to explore the metacognitive aspects of science teachers' awareness of STEM education. Primary school instructors were found to lack science skills, which made it challenging for teachers to create transdisciplinary projects. A conceptual understanding of different themes of science is also lacking. As a result, while teachers practice what they are expected to do in class with their pupils during workshops, theoretical information related to science must also be introduced. To assist instructors in using this strategy, examples of STEM practices created by other teachers have been reinforced (Costa et al., 2020).

“Metacognition involves awareness of how they learn, an evaluation of their learning needs, generating strategies to meet these needs, and then implementing the strategies” (Hacker et al., 2009). The concept of "metacognition" describes the awareness and comprehension of one's mental processes, which enables people to consider and modify their learning tactics. This study used metacognitive exploration to identify the driving forces behind science instructors’ adoption of STEM principles. Preconceived conceptions regarding traditional subject boundaries, available resources, teacher preparation programs, and pedagogical methods are a few examples of these issues.

Additionally, this investigation investigates the degree to which science teachers are aware of the potential advantages of STEM education, including how it can encourage creativity, problem-solving abilities, and critical thinking, and prepare students for the complexities of a constantly evolving world. Policymakers, educators, and institutions can create targeted initiatives to equip science instructors with the information and resources required for delivering STEM education successfully by recognizing the current knowledge and understanding these gaps (Li et al.,2020). However, this necessitates creativity in teaching methods, which is a significant challenge for educators who need professional development to acquire the information and abilities necessary to be successful with this strategy (Anderson, 2020). Teachers also need material and didactic support because their perceptions of STEM education, knowledge, backgrounds, teacher teamwork, and other factors affect their sense of efficacy. (Stohlmann, 2012).

The science teaching approach adopted in Indian schools is largely factual rather than conceptual, informative rather than formative, and product-based rather than process-oriented. Students loose interest in the learning of science and mathematics if they are treated as isolated disciplines without establishing interconnectivity and integration and highlighting real world applications (Kelley et al., 2016).

The primary goal of science teaching is to train young people in the process of scientific thinking rather than the glorification of products. STEM education emphasizes the process of scientific thinking. Unless and until young people are trained rigorously in science culture and scientific temper, the outcome of science teaching will be to fill young people's minds with dead information. In this context, this metacognitive investigation of STEM education knowledge among Indian science instructors is crucial for changing the educational environment in India. This study aims to disentangle the complex web of variables that affect science teachers' adoption and adaptation of STEM principles, ultimately influencing India's workforce and position in the global knowledge economy.

The STEM approach focuses on the exact pathway adopted by scientists in pursuit of great inventions and discoveries. Hence, the learners are trained via the same pathway. This is only possible through a mind that emphasizes and empathizes learning with learning how to learn and think how to think. This necessitates the genuinity and novelty of this research to explore the metacognitive awareness of science teachers. This quest is highly significant in the wider spectrum, and will specifically reveal the perceptions of science teachers pertaining to the intellectual pathway that parallels the STEM approach of science teaching and learning. This quest has been well justified and substantiated from the findings derived from the literature review. The study aims to understand the metacognitive awareness level of science teachers with respect to STEM education and to compare it on the basis of gender, locale (rural/urban), and type of school (public/private). This study also intends to identify strategies used by science teachers to promote STEM education in classrooms, and hypotheses were formulated accordingly.

LITERATURE REVIEW

STEM education is a meta-discipline that integrates science, technology, engineering, and math subjects. (Kennedy et al., 2023). The interlinking of the science pedagogical perspective and allied variances related to teachers have not been explored much from either an empirical or theoretical perspective. The studies identified have been spelt out because of their relevance to the present research. To prepare preservice teachers to teach STEM subjects, Berlin et al. (2012) sought to thoroughly examine preservice teachers' attitudes and perspectives about the integration of science, math, and technology education. To enhance teaching and learning in STEM classrooms and to assist in building and improving preservice teacher education programmes, longitudinal data from the Integrated Mathematics, Science, and Technology (MSAT) Programme over a seven year period, broken down by cohort, are published, analyzed, and interpreted.

High-quality STEM education is essential to children's future success in science, technology, engineering, and mathematics. Making learning more relevant and linked for students may be achieved through integrated STEM education. (Stohlmann et al., 2012) The skills, background, and knowledge that educators require to teach STEM education effectively need to be further investigated and discussed. After a year-long collaboration with a middle school, support, teaching, efficacy, and materials, a model of concerns for teaching integrated STEM education was created. According to a study by Kim et al. (2015), instructors may use robots to assist them in creating and executing science, technology, engineering, and mathematics (STEM) curricula. Their behavioral and cognitive engagement in STEM was impacted by their considerable improvement in their emotional involvement (e.g., curiosity, enjoyment) in STEM. The integration of science, technology, engineering, and mathematics (STEM) in three Florida high school agricultural programmes was examined previously (Stubbs et al., 2015). The perspectives of students and teachers, teacher preparation, demographics, STEM integration, STEM knowledge, and student accomplishment and engagement were all found to be relevant variables in determining effectiveness.

Funded by the U.S. Department of Education, the Idaho SySTEMic Solution is a STEM education initiative designed to advance achievement and confidence among elementary-age learners and their teachers. Nadelson et al. (2013) focused on teachers, with the goal of increasing their STEM content knowledge, instructional practices, awareness of engineering, and overall confidence in their ability to teach STEM concepts. Finding the best instructional design techniques for preservice teachers' training to provide integrated STEM (Evans et al., 2020). Preservice teacher education course developers will have direction when they come to an agreement as a group among experienced teacher educators on the best instructional design approaches to use while integrating STEM education.

Both past and present STEM (science, technology, engineering, and mathematics) educators discuss the difficulties they faced while working at various STEM institutions and argue that teacher preparation programs should pay greater attention to how specialized STEM schools are growing and how this is transforming the face of education both locally and globally (Teo et al., 2014). Based on their experience in organizing and carrying out STEM activities, Bozkurt et al. (2019) explored the reflective assessments of aspiring teachers in STEM education. To create effective STEM teacher education programmes, STEM and Education departments must collaborate across disciplinary boundaries.

Among the countries, US, UK, Australia are leading Science education research (Tosun, 2024), India has a long way to go ahead. Though the education is moving to an inclusive approach there is dearth of data gathering tools to reveal the experiences of the students of underprivileged. (Neally, 2023). There is a wide gap existing in terms of gender in science performance which is an insight for further exploration of under-researched aspects of STEM education. (Rozgonjuk et al., 2024)

Few studies have examined the characteristics that enable STEM and education cooperation to achieve the goal of STEM teacher development in the literature. To improve STEM teacher education programs, the motivation, growth, and sustainability of cooperation between university supervisors and STEM and education faculty are essential. Analysing instructional designs and goals for STEM education, the study (Halawa et al., 2024) examined 229 articles published between 2012 and 2021 and proved a positive link between career choices and engagement, with design-based learning being more widely used to promote STEM literacy. It highlighted the need for more research on Twenty-first century competencies in the future. For students to make the right metacognitive control judgments, they must accurately monitor their metacognitive processes (Morphew, 2021).

Over the last three decades, several attempts have been made in the scientific literature to conceptualize the idea of metacognition. The idea has grown in acceptance across nearly every field, from nursing to communication. Many metacognitive inventories have been created over time because of their popularity. Nevertheless, none of the inventories that are known to exist in the literature are made exclusively for instructors. Metacognitive awareness questionnaire for teachers adapted (Balcikanli, 2011) by utilizing a metacognitive awareness questionnaire designed for adults. This three-phase study was carried out to ensure the validity and reliability of the inventory for use in educational research. The processes for each phase were as follows: creating the items, obtaining outside input and piloting the inventory with student instructors. The researcher adjusted the inventory and based it on the Metacognitive Awareness Inventory (MAI), and the findings of this three-phase investigation confirmed the validity and reliability of the scores on the inventory. Teacher metacognitive awareness seems to be measured with validity and reliability via the MAIT, a modified form of the MAI. Therefore, in the field of educational research, this inventory can be used as a tool to gauge instructors' metacognitive awareness. The metacognitive awareness inventory (MAI) measures that were taken both before and after the 5-week preservice teacher professional development (PD) experience. A fully integrated academic and clinical preparation regimen based on a cognitive coaching model was used to create a PD experience that specifically addressed participants' domain-general and domain-specific knowledge and regulation of cognition. On the basis of all applied factor structures of metacognitive awareness, the results demonstrated an improvement in participants' regulation of cognition.

An extensive survey of the related literature pertaining to metacognitive awareness of STEM reveals that research culture has not percolated specifically into the thinking process of the process approach of STEM. Only a few studies have been conducted on STEM and its application in various ways and means (Thomas & Watters, 2015). Hence, there is a vital need to ponder the cognitive awareness of teachers in STEM and to explore metacognitive pursuits further.

METHOD

The metacognitive awareness of science teachers in STEM education was measured in this study via a descriptive quantitative survey approach. In contrast, the researcher used a distinct descriptive-analytic methodology to investigate how diverse science teachers' metacognitive understanding of STEM education was based on their locality, school type, and gender. The goal of the study is to restrict study participants based on these standards to gather topic-specific data that will be utilized to address the research questions.

Participants

Data were collected for this study from secondary-level science teachers on their metacognitive awareness of STEM. The participants were delimited to the geographical area of Kerala, India. The sample consists of 600 teachers from various schools in different districts selected via random sampling. This study intends to seek and explore awareness based on certain demographics and other variables (Best & Kahn, 2009). The samples are divided into class specific variables based on locality, rural (290) and urban (310); type of school, public (307), private (293); Gender, male (298) and female (302). The sample represents all the population strata.

Instruments used for the study

The five-point Likert-type Metacognitive Awareness Inventory for Science Teachers (MAIST) was designed by the investigators. An inventory used to assess the metacognitive awareness of primary teachers in Jordan (Haddad et al., 2022) was identified. Taking advantage of this essential conceptualization and the different assessment mechanisms used by the authors and researchers, the researchers developed a five-point Likert-type metacognitive awareness inventory for science teachers (MAIST) to assess teachers' metacognitive awareness of STEM education. The tool used was metacognitive awareness of STEM education by teachers at different levels via a Likert scale. The MAIST consists of 52 items on a 5-point scale. The developed MAIST consists of two main parts: (A) Knowledge about cognition with sub-dimensions: informative knowledge (8 items), operational knowledge (4 items), substantial knowledge (5 items), and; (B) Regulation of cognition with the following subdomains: preparedness (7 items), assessing comprehension (7 items), knowledge processing strategies (9 items), revamping strategies (4 items), introspection (5 items) and peer scaffolding (2 items).

In several disciplines, including psychology, neuroscience, education, and artificial intelligence, having a solid understanding of cognition is essential. Subdimensions can be used to group many degrees and facets of cognition knowledge. The fundamental comprehension of ideas, concepts, and cognitive processes is referred to as informative knowledge. Knowing the circumstances that affect cognitive processes and results is known as circumstantial knowledge. The influence of environmental or situational factors on cognition is examined in this subdimension. Cultural variations in cognitive functions, including memory, perception, and problem solving, as well as their effects on cognitive growth and functioning, exist. The state of being equipped or ready to participate in cognitive tasks or activities is referred to as preparedness. To effectively confront cognitive obstacles, one must possess the requisite information, skills, resources, and mentality, as well as be behaviorally and mentally prepared. Evaluating a person's comprehension and interpretation of ideas or information delivered in different formats (e.g., text, images, aural stimuli) is known as an assessment of comprehension. It entails evaluating the breadth of comprehension, the capacity to deduce meaning, and the ability to form connections or draw conclusions. The term "knowledge processing strategies" describes the mental processes involved in gathering, encoding, storing, retrieving, and modifying information in memory. These techniques cover a variety of thought processes and actions meant to improve memory, learning, and problem-solving skills. People use a variety of cognitive processes, including rehearsal, elaboration, organizing, visualization, chunking, and mnemonic procedures, as part of their knowledge-processing strategies to make sense of new material and integrate it with their prior knowledge. These techniques maximize cognitive efficiency, encourage information transfer and retention, and support adaptable problem-solving and flexible thinking. The process of updating, modifying, or altering cognitive processes, behaviors, or mental frameworks in response to difficulties, setbacks, or evolving conditions is known as revamping tactics. These techniques include problem-solving abilities, cognitive flexibility, and the capacity to overcome difficulties or failures. Revamping tactics are methods that people employ to address difficult or unclear situations, including cognitive restructuring, problem reframing, goal reevaluation, and adaptive coping mechanisms. They entail questioning presumptions, looking at many angles, and coming up with fresh ideas to accomplish goals to eventually foster creativity, resilience, and improvements in cognitive functioning. The processes of self-reflection, self-awareness, and self-examination of one's ideas, feelings, beliefs, and experiences are referred to as introspection. To obtain insight and understanding of oneself, it entails looking inward to investigate and examine one's thoughts, motives, and behaviors.

Metacognitive processes, including tracking one's cognitive activity, assessing one's performance, and controlling one's thoughts and emotions, are all part of introspection. It helps people become more conscious of their cognitive assets and limitations, spot thought or behavior patterns, and obtain a deeper comprehension of their own thought processes. The process of cooperative help, support, and direction given by peers to aid in learning, problem-solving, or skill development is known as peer scaffolding. It entails peers interacting with one another, working together, and exchanging resources and expertise to improve comprehension and task accomplishment. Peer scaffolding is the process by which peers collaborate to offer each other constructive criticism, modeling, support, and encouragement while they work on academic or cognitive tasks. It creates a collaborative and encouraging learning environment that is advantageous to all participants by encouraging social contact, active involvement, and shared accountability for learning results.

With this theoretical conceptualization, the domain and subdomains were customized to match the integration of science, technology, engineering and mathematics and its awareness and the way the thinking process proceeded. There are 52 items in this inventory, which are distributed across 9 dimensions. For every item, there are five possible responses: strongly agree, agree, neutral, disagree, and strongly disagree. The respondent must indicate their stance by a tick mark in the box next to the item that best fits their needs.

Data collection procedure

The investigator approached the participants and distributed the MAIST. Prior instructions were given about the relevance of the study. The teachers were asked to express their responses to each item. Altogether, 600 data points were obtained. The data were subjected to analysis according to the objectives and hypotheses formulated. The results obtained from the analysis and the interpretations and discussions are presented in the following subheadings.

Existing level of metacognitive awareness among science teachers in STEM education

The obtained data were subjected to descriptive analysis, such as the mean, median, mode, standard deviation, skewness and kurtosis, to calculate the scores for the locality, type of school and gender of the science teachers. The results obtained are presented in Table 1.

Table 1: Metacognitive awareness among science teachers in STEM education.

	Locality			Type of school			Gender		
Meta-cognitive awareness	Total N=600	Urban N=310	Rural N=290	Total N=600	Private N=293	Public N=307	Total N=600	Female N=302	Male N=298
Mean	157.36	162.78	150.75	187.78	194.17	182.29	125.76	126.95	127.47
Median	160	165	152.5	187	195	186	122	123	124
Mode	166	166	167	190	198	190	126	126	130
SD	25.24	24.06	24.71	28.4	30.67	25.24	32.95	29.65	37.83
Skewness	-0.31	-0.27	-0.21	0.08	-0.08	-0.14	0.34	0.39	0.27
Kurtosis	-0.74	-0.78	-0.85	0.31	0.15	0.57	-0.5	-0.51	-0.7
Percentage	62.94	65.55	60.3	70.86	73.27	68.41	45.27	44.98	45.56

Note: SD = Standard Deviation

Table 1 clearly shows that the means, medians and modes of all the groups are almost the same. The standard deviation of the groups of these variables indicates that the score is somewhat dispersed from the central value. The statistical properties of the sample, which are based on the subdomains of the metacognitive awareness inventory, are presented in Table 2.

Table 2: Descriptive Statistical properties of the subdomains (N= 600)

Sl. No	Subdomains	Mean	Median	Mode	SD	Skewness	Kurtosis
1	Informative Knowledge	63.84	63	64	2.34	1.08	1.6
2	Operational Knowledge	55.86	56.8	58	2.62	-0.8	1.28
3	Circumstantial Knowledge	56.96	57.8	58	3	-0.39	-0.33
4	Preparedness	59.22	60.9	64	2.81	-0.46	-0.28
5	Knowledge Processing Strategies	70.14	71.4	67	3.44	-0.49	-0.24

6	Assessing Comprehension	72.24	73	72	9.77	-0.17	-0.79
7	Revamping Strategies	77.7	79.8	76	3.57	-0.61	-0.31
8	Introspection	65.1	67.2	63	3.01	-0.72	0.09
9	Peer Scaffolding	81.48	84	82	3.74	-0.93	0.64
	TOTAL	**603.54**	**616.9**	**592**	**24.49**	**-0.3**	**-0.52**

Note: SD = Standard Deviation

Comparison of metacognitive awareness among science teachers in STEM education based on select class-specific variables.

To determine the differences in metacognitive awareness in STEM education among science teachers in terms of gender, type of school and, locality, the mean and standard deviation were found separately, followed by t-test. The data and results are presented in Table 3.

Table 3: Metacognitive awareness based on gender, location, and type of school.

Variables		N	Mean	Standard Deviation	t-value
	Female	302	163.87	24.06	6.59**
Gender	Male	298	150.75	24.71	
	Total	600	157.36	25.24	
	Private	307	194.17	30.68	
Type of School	Public	293	181.29	24.26	5.70**
	Total	600	187.78	28.40	
	Urban	310	125.95	29.65	0.58(NS)
Locality	Rural	290	127.57	37.83	
	Total	600	126.76	33.94	

**Significant at the 0.01 level

Table 3 shows that the total sample and subsamples had an average level of metacognitive awareness. The t value between the mean scores of the female and male subsamples (6.59) indicates that there is a significant difference between the metacognitive awareness of the male and female subsamples at the 0.01 level of significance. The mean and standard deviation of the type of school for the total sample are 187.78 and 28.40, those of the public sample are 194.17 and 30.68, and those of the private sample are 181.29 and 24.26, respectively. The t value between the means of the private and public samples of 5.708 indicates that there is a significant difference between the metacognitive awareness of the private and public-school subsamples at the 0.01 level of significance. These findings indicate that public school teachers have a greater level of metacognitive awareness than private science teachers. This finding indicates that the mean scores and standard deviations of locality for the total sample are 126.76 and 33.94 for the total sample, 125.95 and 29.65 for the urban sample and 127.57 and 37.83 for the rural sample, respectively. The t value of the difference between the mean scores of the urban and rural samples (0.584) indicates that there is no significant difference in the metacognitive awareness of science teachers between the urban and rural samples at the 0.05 level of significance. This shows that urban and rural teachers are almost equal in terms of the variable locality.

Classroom strategies adopted by science teachers for STEM education

The researchers observed the science classes of the teachers and interviewed them. All the observations and the responses to the interviews were pooled. Further analysis has led researchers to arrive at the following conclusions.

- although there has been a wider shift in the curriculum from pedagogical imposition to a praxis-oriented approach, there has been no specific and concerted effort to promote STEM.
- there are some scattered and isolated efforts endured by some teachers, especially in relation to science club activities.
- approaches such as projects and problem-based learning are reflected in the curriculum.
- there is no enough integration of the STEM approach during curricular articulation, and each domain is treated as an independent discipline.
- prominently, the activities of STEM integration are limited in the preparation of projects and working models that are needed for science exhibitions and science fairs.
- the heuristic approach, which is the cardinal spirit for promoting STEM education, is lacking, and science pedagogy is littered with factual rhetoric narrations.
- the physical and academic climate of the institution is also not congenial for designing and implementing STEM education.

DISCUSSION AND CONCLUSIONS

Science teachers had an average metacognitive awareness of STEM education in terms of their understanding of cognition. This outcome is explained by the pressing necessity for educators to keep up with the quick changes occurring in every area of life, including education. Because it provides a better way to grasp education goals, it highlights the significance of metacognitive awareness in education. If we do not have a modest amount of metacognitive awareness of the techniques we are employing, it is difficult to improve the teaching process. Helping students recognize and accept responsibility for their learning is essential if one of the education objectives is to equip them with the skills necessary to be lifelong learners. Teachers' interests have been piqued, and they are now under pressure to advance their techniques of instruction. The results of the study (Sevian et al., 2018) are consistent with this conclusion. In their study, they demonstrated how, in recent years, research on STEM education has progressed and has piqued the attention of both teachers and students. Because instructors may now finally recognize and comprehend what they teach as well as the entire teaching process, the researcher discovered that the metacognitive degree of awareness significantly influences cognition. This outcome is consistent with the conclusion drawn from this investigation. Among the metacognitive methods used by primary school teacher candidates, "self-control," "cognitive strategy," "self-evaluation," and "self-awareness" are the most often employed methods (Boice et al., 2021).

The state of STEM education in India, like in many other parts of the world, is critical for encouraging creativity and equipping students with a world that is becoming increasingly dependent on technology. The negative consequences of teacher overload on the standard of instruction have been highlighted by several studies. Overwhelming workload can cause teacher burnout, which compromises the quality of education and student results (Darling et al., 2007). Overloading teachers becomes a major barrier in STEM education, which requires creative teaching strategies and ongoing professional development (Ingersoll et al., 2012). Educators must stay up to date with quickly changing technology and instructional approaches. This underscores the need to schedule time for professional development and cooperation.

According to a survey (Jerrim & Sims, 2019), teachers in many nations, including India, reported high levels of administrative obligations, leaving little time for professional development and collaborative activities. Peer scaffolding and collaborative learning among instructors are acknowledged as successful ways to increase STEM education awareness; thus, this lack of time for collaboration is especially troubling in a STEM environment (Dorph et al., 2018). Years of experience and involvement in training change teachers' perceptions of STEM significantly and hence there is a need for raising teachers' awareness of STEM education and the its implementation. (Alsalamat, 2024). Teachers face several stresses, such as excessive workloads, dearth of resources, and a lack of opportunities for professional development. These pressures may make it more difficult for STEM education programs to be implemented successfully.

IMPLICATIONS

The educational landscape is undergoing a pragmatic shift at the global and local levels due to the evolution and introduction of approaches such as STEM. Empirical observations and validation significantly reinforce STEM as a potential tool to bring about positive changes at the micro and macro levels, which will calibrate the individual and social living canvas. To catalyze this progressive drive, the learners must be converted and redefined as custodians of their learning. Hence, they must train their cognitive thinking and further move beyond cognition. This approach can be integrated into curricular transactions by teachers, especially science teachers. Hence, teachers need to have an understanding of STEM education and its prospects. There can be regional, rural, school type and gender variations. The ultimate aim is to explore the idea and spirit of STEM education. Ongoing professional development and teacher preparation are prioritized over training in STEM education (Honey et al., 2014). Training that is in line with modern pedagogical techniques is needed for science teachers to support experiential and inquiry-based learning in the classroom. Concerted and specific treatment in STEM should be a priority both during preservice and in-service teacher education programs. Addressing the education issues of India can be visualized as a transition stage, as the educational landscape of the country is at a crossroads with the implementation of the National Education Policy (NEP, 2020). NEP 2020 acknowledges scientific education as a pillar for innovative thinking, holistic growth, and the development of vital skills necessary for the ever-changing demands of society. The policy offers a thorough framework that encourages the incorporation of science instruction at different levels, guaranteeing its applicability and efficacy in producing citizens who are well-rounded and knowledgeable about science. This will lead to a transformative education as visualized by NEP 2020.

REFERENCES

Alsalamat, M. K. M. (2024). Secondary Stage Science Teachers' Perceptions toward STEM Education in Saudi Arabia. *Sustainability*, *16*(9), 3634. https://doi.org/10.3390/su16093634

Anderson, J. (2020). The STEM education phenomenon and its impact on school curriculum. *Curriculum Perspectives*, *40*(2), 217-223.

Balcikanli, C. (2011). Metacognitive awareness inventory for teachers (MAIT). https://doi.org/10.25115/ejrep.v9i25.1620

Beach, D., Bagley, C., Eriksson, A., & Player-Koro, C. (2014). Changing teacher education in Sweden: Using meta-ethnographic analysis to understand and describe policy making and educational changes. *Teaching and teacher education*, *44*, 160-167. https://doi.org/10.1016/j.tate.2014.08.011.

Berlin, D. F., & White, A. L. (2012). A longitudinal look at attitudes and perceptions related to the integration of mathematics, science, and technology education. *School science and mathematics*, *112*(1), 20-30. https://doi.org/10.1111/j.1949-8594.2011.00111.x

Best, J. W., & Kahn, J. V. (2009). Research in Education New Delhi, Printice Hall of India Pvt.

Boice, K. L., Jackson, J. R., Alemdar, M., Rao, A. E., Grossman, S., & Usselman, M. (2021). Supporting teachers on their STEAM journey: A collaborative STEAM teacher training program. *Education Sciences*, *11*(3), 105. https://doi.org/10.3390/educsci11030105

Bozkurt, A., & Özyurt, M. (2019). Investigate the Evaluations of Prospective Teacher on STEM Education, Based on Their Experiences with Planning and Implementing STEM Activities. *Malaysian Online Journal of Educational Technology*, *7*(4), 81-97.

Brown, J. (2012). The current status of STEM education research. *Journal of STEM Education: Innovations and Research*, *13*(5).

Costa, M. C., Domingos, A., & Teodoro, V. (2020). Promoting integrated STEM tasks in the framework of teachers' professional development in Portugal. *Integrated Approaches to STEM Education: An International Perspective*, 511-532. https://doi.org/10.1007/978-3-030-52229-2_27

Darling-Hammond, L., Hyler, M. E., & Gardner, M. (2017). Effective teacher professional development. *Learning policy institute*. USA

Dorph, R., Bathgate, M. E., Schunn, C. D., & Cannady, M. A. (2018). When I grow up: The relationship of science learning activation to STEM career preferences. *International Journal of Science Education*, *40*(9), 1034-1057. https://doi.org/10.1080/09500693.2017.1360532

English, L. D. (2016). STEM education K-12: Perspectives on integration. *International Journal of STEM education*, *3*, 1-8. https://doi.org/10.1186/s40594-016-0036-1

Evans, C. A., Chen, R., & Hudes, R. P. (2020). Understanding determinants for STEM major choice among students beginning community college. *Community College Review*, *48*(3), 227-251. https://doi.org/10.1177/0091552120917214

Government of India. (2020). National Education Policy 2020. Ministry of Human Resource Development. https://www.education.gov.in/sites/upload_files/mhrd/files/NEP_Final_English_0.pdf

Hacker, D. J., Keener, M. C., & Kircher, J. C. (2009). Writing is applied metacognition. In *Handbook of metacognition in education* (pp. 154-172). Routledge.

Haddad, F., Tabieh, A. A., Alsmadi, M., Mansour, O., & Al-Shalabi, E. (2022). Metacognitive Awareness of STEAM Education among Primary Stage Teachers in Jordan. *Journal of Turkish Science Education*, *19*(4), 1171-1191.

Halawa, S., Lin, T. C., & Hsu, Y. S. (2024). Exploring instructional design in K-12 STEM education: a systematic literature review. *International Journal of STEM Education*, *11*(1), 43. https://doi.org/10.1186/s40594-024-00503-5

Honey, M., Pearson, G., & Schweingruber, H. A. (Eds.). (2014). *STEM integration in K-12 education: Status, prospects, and an agenda for research* (Vol. 500). Washington, DC: National Academies Press.

Ingersoll, R. M., & Strong, M. (2012). What the research tells us about the impact of induction and mentoring programs for beginning teachers. *Teachers College Record*, *114*(14), 466-490. https://doi.org/10.1177/016146811211401411

Jerrim, J., & Sims, S. (2019). *The teaching and learning international survey (TALIS) 2018*. London: Department for Education. https://assets.publishing.service.gov.uk/media/5f6484d9e90e0759f55755ed/TALIS_2018_research_brief.pdf

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM education*, *3*, 1-11. https://doi.org/10.1186/s40594-016-0046-z

Kennedy, T. J., & Odell, M. R. (2023). STEM Education as a Meta-discipline. In *Contemporary issues in science and technology education* (pp. 37-51). Cham: Springer Nature Switzerland. https://doi.org/10.1007/978-3-031-24259-5_4

Kim, C., Kim, D., Yuan, J., Hill, R. B., Doshi, P., & Thai, C. N. (2015). Robotics to promote elementary education pre-service teachers' STEM engagement, learning, and teaching. *Computers & education*, *91*, 14-31. https://doi.org/10.1016/j.compedu.2015.08.005

Li, Y., Wang, K., Xiao, Y., & Froyd, J. E. (2020). Research and trends in STEM education: A systematic review of journal publications. *International journal of STEM education*, *7*, 1-16. https://doi.org/10.1186/s40594-020-00207-6

Morphew, J. W. (2021). Changes in metacognitive monitoring accuracy in an introductory physics course. *Metacognition and Learning*, *16*(1), 89-111. https://doi.org/10.1007/s11409-020-09239-3

Nadelson, L. S., Callahan, J., Pyke, P., Hay, A., Dance, M., & Pfiester, J. (2013). Teacher STEM perception and preparation: Inquiry-based STEM professional development for elementary teachers. *The Journal of Educational Research*, *106*(2), 157-168. https://doi.org/10.1080/00220671.2012.667014

Neally, K. (2023). Underrepresentation of Minoritized Groups in STEM Education: The Development of a Survey. *Journal of Interdisciplinary Studies in Education*, *12*(1), 146-169.

Rozgonjuk, D., Täht, K., Soobard, R., Teppo, M., & Rannikmäe, M. (2024). The S in STEM: gender differences in science anxiety and its relations with science test performance-related variables. *International Journal of STEM Education*, *11*(1), 45. https://doi.org/10.1186/s40594-024-00504-4

Sevian, H., Dori, Y. J., & Parchmann, I. (2018). How does STEM context-based learning work: What we know and what we still do not know. *International Journal of Science Education*, *40*(10), 1095-1107. https://doi.org/10.1080/09500693.2018.1470346

Stohlmann, M., Moore, T. J., & Roehrig, G. H. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research (J-PEER)*, *2*(1), 4. https://doi.org/10.5703/1288284314653

Stubbs, E. A., & Myers, B. E. (2015). Multiple case study of STEM in school-based agricultural education. *Journal of Agricultural Education*, *56*(2), 188-203. https://doi.org/10.5032/jae.2015.02188

Teo, T. W., & Ke, K. J. (2014). Challenges in STEM teaching: Implication for preservice and inservice teacher education program. *Theory into Practice*, *53*(1), 18-24. https://doi.org/10.1080/00405841.2014.862116

Thomas, B., & Watters, J. J. (2015). Perspectives on Australian, Indian and Malaysian approaches to STEM education. *International Journal of Educational Development*, *45*, 42-53. https://doi.org/10.1016/j.ijedudev.2015.08.002

Tosun, C. (2024). Analysis of the last 40 years of science education research via bibliometric methods. *Science & Education*, *33*(2), 451-480. https://doi.org/10.1007/s11191-022-00400-9

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