

Awareness, Perception and Attitude of In-Service Teachers Towards Integrated STEM Education

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Abstract

The present study examines the awareness, perception, and attitude of in-service teachers towards integrated STEM (Science, Technology, Engineering, and Mathematics) education in the Indian school context. With the increasing emphasis on 21st-century skills such as critical thinking, creativity, and problem-solving, STEM education has emerged as a significant pedagogical approach. The study adopts a quantitative descriptive research design and was conducted among in-service teachers from schools equipped with Atal Tinkering Labs in Vadodara. Data were collected using structured questionnaires and an attitude scale to measure teachers' awareness, perception, and attitude towards STEM education.

The findings indicate that teachers possess a moderate level of awareness regarding integrated STEM education, though conceptual clarity varies across participants. The perception of teachers towards STEM is largely positive, recognising its role in enhancing student engagement, interdisciplinary learning, and real-life application of knowledge. Additionally, teachers demonstrate a favourable attitude towards adopting STEM practices in classrooms. However, challenges such as a lack of professional training, inadequate infrastructure, time constraints, and limited interdisciplinary expertise hinder effective implementation.

The study concludes that while teachers show readiness and positive inclination towards STEM education, systematic efforts in teacher training, curriculum restructuring, and institutional support are essential for its successful integration in school education.

Keywords: STEM Education, Integrated STEM, Teacher Awareness, Teacher Perception, Teacher Attitude, In-Service Teachers, 21st Century Skills, Atal Tinkering Labs

1. Introduction

The acronym STEM (science, technology, engineering and mathematics), proposed by the American National Science Foundation (NSF), is now widely accepted and used to express a specific knowledge and application area today.

In the educational space the word "STEM Education" is frequently heard nowadays. STEM is an acronym for Science, Technology, Math and Engineering. Day by day it is gaining popularity due to rapid developments in these fields. Several reports have shown that not only do a majority of our potential jobs fall into this category but that many new jobs will be created in these regions. It should be noted that the STEM fields have the same impact on all other areas, be they arts, humanities or some other field. STEM skills will be of great economic importance in a world which is rapidly developing and

inclined towards technology. At a crucial time when the Indian government is supporting initiatives like Make in India, Skill India, digital India to promote manufacturing, technology use and skills development in the country, STEM turns out to be an important and integral part of our education (Malti, 2017)

However, even from a very wide perspective, when we look at the existing Indian education system, we clearly find that we are far behind in adjusting to the changes in the global educational arena. Even today, learning by textbook is a big focus on our school education system and, in most cases, secured marks are the only criterion for evaluating skills. Critical thinking, inquiry based learning and hands-on learning is something which is far from implementation especially in a majority of K-12 educational institutions (Sharma, 2018) Curiosity, innovation and a passion for knowledge for Science, Technology, Engineering and Math (STEM) in children can be promoted by early exposure to hands on learning and practical skills in a more engaging and enjoyable environment to learn. When a kid discovers a passion for STEM fields, it smoothes the decision-making process to pick the right field for career pursuance. It will help to create great thinkers, innovators, engineers and scientists that our society and industry needs (Kavya, 2019). As said earlier, it is needed for our future prosperity and to our nation in order to develop competitiveness and play a vital role in global economy.

In India though many schools have started STEM education but still very less work is done at the concrete level. Even the Indian Government have started many programmes like Atal Tinkering labs, Atal Incubation centre, All India Council of Robotics and Automation (AICRA) India STEM Summit, INSPIRE-MANAK Awards etc. and currently promoting many initiatives such as Make in India, Skill India and Digital India to promote STEM education but still many teachers don't know how to teach using STEM integration approaches in their classroom. Very little research exists on how schools interpret and implement STEM education. This may be due to the overall lack of a coherent definition of STEM education by major education organizations. Therefore, there is a need to understand how schools interpret and implement STEM.

Keeping all this in mind, the investigator, in the proposed study try to study the awareness, perception and attitude of in-service teachers about integrated STEM education. The investigator would like to conduct the study in Vadodara schools where Atal Tinkering Labs (ATLs) are established and STEM education is promoted.

Accordingly, this study is guided by the following research questions:

RQ1: How far have the in-service school teachers gained insight about STEM education?

RQ2: How have the in-service teachers conceptualised STEM education?

RQ3: What kind of educational setting will facilitate STEM education?

2. Literature Review

Review of related literature gives a clear idea to the researcher about the researchers that have been conducted in his/ her field of research. Although the area of STEM education is relatively new in Indian context, a considerable amount of literature exists in abroad. Filtering out the most relevant studies, an attempt has been made to develop a holistic perspective of the nature and findings of these studies and to draw implications for the present study. In this regard therefore, the most relevant work (25 studies) have been reviewed here.

According to Breiner et.al (2012) STEM is a variety of activities which will replace traditional lecture-based teaching strategies with more inquiry and project based approaches. Lamberg & Trzynadlowski

(2015) suggested that STEM education is a carefully designed instructional sequences which are connected to real world applications whereas El-Deghaidy & Mansour (2015) interpreted that teacher's deep content knowledge, innovative teaching strategies, interdisciplinary learning and the development of strong teams are important for teachers to introduce STEM education into their schools. Sumen & Calisici (2016) conducted study on the associating abilities of pre-service teachers science education program acquisitions with engineering using STEM education and suggested that teaching pre-service teachers in the use of STEM allows them to apply it easily to their lessons during their vocational life. Nuangchalerm (2018) who studied the perception of in- service primary teachers on STEM education in Thailand interpreted that STEM education not only needs to focus on content knowledge but also needs to include thinking skills and 21st century learning skills whereas Wang et.al (2011) viewed STEM integration as multidisciplinary and interdisciplinary. In the multidisciplinary approach a learner could easily identify each subject. In contrast an interdisciplinary approach is like a melting point in that the boundaries among subjects are blurry.

The in-service teachers' perception towards integrated STEM education and how they conceptualise it has been studied by Breiner et.al (2012), Lamberg & Trzynadlowski (2015) El-Deghaidy & Mansour (2015), Altan & Ercan (2016), Sumen & Calisici (2016) , Madden et.al (2016), Nuangchalerm (2018) and Kanadlı (2019)

In addition to these studies, Wang et.al (2011), Sayary et.al (2015), Akran & Aşıroğlu (2018) and Admawati & Jumadi (2018) focused on the relationship between STEM education and Constructivist education approach and how it is affecting the teaching-learning process. Whereas Altin & Pedaste (2013), Khanlari (2013) and Holmquist (2014) have examined the impact of educational robots on learning STEM and students' attitude towards educational robot.

Chia & Maat (2018) identified the level of attitudes towards the integration of STEM among secondary school teachers in Malaysia. Whereas Timur et.al (2019) investigated the effect of STEM based activities on in-service teachers' views about STEM teaching.

Tekerek & Karakaya (2018) aimed to determine pre-service science teachers' STEM awareness in terms of different variables. The purpose of the study conducted by Buyruk & Korkmaz (2016) is describing teacher candidates' awareness levels related to STEM. Madden, Beyers and O'Brien(2016) studied how pre-service and novice teachers view the importance of STEM education in the elementary grades. A sample of prospective and early career elementary teachers was surveyed using an anonymous online questionnaire. The purpose of the study conducted by Han & Yalvac(2015) was to explore teachers' understanding and implementation of STEM Project Based Learning activities using a qualitative case study approach. Thus the research question explored through this study was, "After sustained Professional Development on STEM PBL, what were the participating mathematics and science teachers' understanding of and attitude towards STEM PBL and how did they implement STEM PBL in their classrooms (enactment)?"

Sharma & Yarlagaddab (2018) and Kavya & Rishinath (2019) studied the Indian government's initiatives towards STEM education, the potential future challenges that India could face in STEM education at the school level and the awareness of academicians towards government's initiative like Atal Tinkering Labs etc.

In terms of research techniques Wang et.al (2011) , Breiner et.al (2012), El-Deghaidy & Mansour (2015), Lamberg & Trzynadlowski (2015) ,Altan & Ercan (2016), Han & Yalvac(2015) and Sumen & Calisici (2016) adopted qualitative case study. Admawati & Jumadi (2018) conducted quantitative

research with one group pre-test and post-test of quasi-experiment. Akran & Aşıroğlu (2018) adopted phenomenography as a qualitative research method. Kavya & Rishinath (2019) conducted quantitative research and used Chi-square test for testing the hypothesis. Dönmez and Taşar (2020) adopted self-study design as one of the qualitative research method. But in studies like Altin and Pedaste (2013), Sharma and Yarlagađab (2018) and Kanadlı (2019) systematic literature review was conducted. Holmquist (2014) adopted multi-case study approach whereas Khanlari (2013) adopted qualitative approach in which data are collected through a focus group and to enhance the credibility of the findings, all the statements were recorded, precise description and member checks were utilized. Whereas Chia & Maat (2018) conducted small-scale survey and collected data were analysed using SPSS software, descriptive analysis included percentage and correlation analysis has been utilized to evaluate the collected data. Timur et.al (2019) used pre-test and post-test research design to investigate teachers' reactions to STEM based activities. "Pre-service Teachers' Integrative STEM Teaching Intention Questionnaire" was used to measure teachers' views on STEM teaching. The results showed that STEM based activities had a positive effect on teachers' views about STEM education. Tekerek & Karakaya(2018) used "STEM Awareness Scale (SAS)" as data collection tool, and the data were analyzed using IBM SPSS-21 statistical program. For data analysis, Independent t test, variance analysis (ANOVA) and Tukey significance test were used. Even Buyruk & Korkmaz (2016) also used "STEM Awareness Scale (SAS)" as data collection tool.

In terms of sampling techniques most of the researchers have adopted either purposive sampling or convenience sampling techniques in their studies. In terms of selection of the sample, the investigator observed wide variation. Wang et.al (2011) conducted study with 3 middle school in-service teachers purposefully selected from a pool of teachers involved in a yearlong professional development module on STEM integration. Breiner et.al (2012) carried out study among full-time faculty members of University of Cincinnati. Khanlari (2013) conducted study on 6 robotics teachers who have at least two years' experiences of teaching robotics in schools. Lamberg & Trzynadlowski (2015) conveniently selected 7 teachers from 3 STEM academies for their study. El-Deghaidy & Mansour (2015) and Altan & Ercan (2016) conducted their study on in-service science teachers. Sumen & Calisici (2016) selected pre-service teachers of Ondokuz Mayıs University for their study. Nuangchalerm (2018) carried out his study by purposively selecting 120 STEM teachers from 40 STEM schools in Thailand. Akran & Aşıroğlu (2018) conducted study on 40 primary school teachers, 30 mathematics teachers, 20 science teachers and 15 information technologies teachers, who serve in the city center of Siirt and Batman (Turkey). Kavya & Rishinath (2019) carried out study with 100 in-service teachers selected through convenience sampling method from the schools having Atal Tinkering Labs. Chia & Maat (2018) purposively selected 55 secondary school teachers as the sample for their study. The participants in Timur et.al (2019) study were 39 in-service teachers from different majors who were working as teachers in public schools in Turkey. Tekerek & Karakaya(2018) collected data from 148 pre-service science teachers studying at a state university in Turkey who were chosen through the convenience sampling method.

Through the review investigator noticed that majority of the researchers carried out qualitative case-study method. The other interesting thing which investigator noticed that majority of the studies were carried out among in-service teachers.

For the purpose of data collection, open-ended questionnaire and interview schedule has been invariably used by many researchers. However, Wang et.al (2011) used document analysis and classroom

observation and Dönmez & Taşar (2020) used in-class video recording and post-lesson diaries as data collection tool. Tekerek & Karakaya(2018) used "STEM Awareness Scale (SAS)" developed by Buyruk and Korkmaz (2016) as data collection tool. It was a 5-point Likert type scale and consisted of 17 questions with 2 factors. Data sources in the study conducted by Han & Yalvac (2015) were (a) each participant's lesson plans, (b) an in-class participant observation, and (c) one-on-one semi- structured interview

In addition to this, very few studies have referred to secondary sources of data to strengthen their data analysis.

A brief discussion of the findings of these studies is presented below:

The study of Lamberg & Trzynadlowski (2015) on the perception of in- service teachers towards STEM education revealed that teachers at each STEM academy school conceptualised and implemented STEM differently, it is actually based on the way they interpreted STEM and the resources they had access to. Similarly, Breiner et.al (2012) also found in their study that teachers do not share a common conceptualisation of STEM. Their conception is most likely based on their academic discipline or how STEM impacts their daily lives. While in many studies like El-Deghaidy and Mansour (2015), Altan and Ercan (2016), Madden et.al (2016) , Nuangchalerm (2018) and Kanadlı (2019) it was found that in-service teachers have only a fragmented understanding of the significance of STEM education especially at elementary levels and the studies also suggested that in-service training programs should be developed for teachers to raise their awareness of the necessity of STEM education and to enhance their competencies in planning, implementation and evaluation of an instructional process suitable for this approach. And also this approach would help students to increase their interest in engineering, changing technological advancements and the learning processes would be more effective. Sumen and Calisici (2016) found that pre-service teachers could easily associate elementary education science lessons acquisitions with the field of engineering. Thus, the pre-service teachers should be trained on STEM because they have the ability to implement STEM activities. The study of Chia & Maat (2018) on the teacher's attitude towards integration of STEM in Malaysia revealed that overall attitude of teachers are positive and the positive attitude towards STEM among the teachers can expedite the forming of integrated STEM education in Malaysia and it is expected that the results could provide useful information to the relevant stakeholders in formulating the implementation strategy for the integrated STEM education in Malaysia. Timur et.al(2019) concluded that STEM training course promoted teachers' views about STEM integration. Also teacher professional development program plays crucial role in training teachers, because it can not be expected of pre-service teacher training programs to prepare teachers throughout their careers due to the role of schools are changing over time. Also their study supported the view that teachers' positive view development regarding STEM education is important for future science education. Because teachers' views regarding a subject were positively associated with the good teaching. Also STEM should not be seen as an educational approach that just used by science or math teachers. In this study, their analyses demonstrated that teachers' increase of test scores regarding STEM teaching are independent of their branches. This shows that teachers in all branches (computer teacher, chemistry teacher, math teacher, geography teacher, english teacher, guidance teacher, pre-school teacher etc.) are positively influenced by STEM training course.

With regard to STEM Awareness Tekerek & Karakaya(2018) concluded that there is no statistically significant difference in pre-service science teachers' STEM awareness in terms of gender, academic achievement score, technology usage frequency, and family income level. While they significantly differ

in their STEM awareness with regard to grade level. Whereas Buyruk & Korkmaz (2016) concluded that general STEM awareness levels of teacher candidates are quite high and gender has no effect on teacher candidates' STEM awareness. The findings of the study conducted by Han & Yalvac (2015) indicated that the Professional Development sessions were effective in communicating several important concepts about STEM Project Based Learning. The teachers in this study were able to understand and explain what STEM PBL was in comparison with the knowledge-centered or teacher-centered instruction. Most teachers observed in this study acknowledged that STEM PBL was critical and effective in stimulating students "interests and improving students" understanding of content.

With regard to the relationship between STEM education and constructivist education approach, Akran and Aşıroğlu (2018) revealed that both STEM education and constructivist education approach are student centred and both approaches handle children with a comprehensive concept of education (cognitive, affective and psychomotor domains), aim for children's learning by doing and experiencing, emphasize on scientific process skills, and expect that theoretical knowledge are converted into practice. Based on social constructivism theory Admawati and Jumadi (2018) revealed that STEM project based learning developed open-mindedness and cooperation with others because every student did their project with their peers in the group. Based on Vygotsky, this condition can help a learner work effectively with support, dialogue with peers to share ideas, and move across the zone of proximal development. Besides that, STEM PjBL gave significant effect on student's curiosity which indicates social constructivist teacher's success on helping students find their passions, helping student discover what they care about, providing self-expression through a variety of media, and helping student understand that they are co-constructors of knowledge that they can make sense of things themselves. Similarly, the study of Wang et.al (2011) recommended that STEM integration approach is grounded in the tenets of constructivism. Also the problem solving plays an important role in integrating engineering into science and mathematics. However, they also think prior knowledge, such as science and mathematics content knowledge, is important for students to understand in order to be successful in STEM integration.

Several studies show that teachers are well versed in their subject matter knowledge but they lack of skills in STEM education (H. El-Deghaidy, 2015). According to Wang et. al. (2011), this problem primarily depends on the lack of instructions for teachers to the use of STEM education effectively in classrooms. Srikoorn, Hanuscin and Faikhamta (2017) claimed that teachers should be given guidelines on how to integrate STEM education into their classrooms. Another limiting factor is that teachers' inadequate content knowledge in other disciplines because STEM education means interaction with four disciplines. Sanders (2009) indicated that STEM education requires teachers to be expert not only in their subject but also requires them to be informed at least one other STEM subject. All of these inadequacies affect teachers' STEM implementation (National Academy of Engineering and National Research Council, 2014).

With regard to role of educational robots in STEM education Holmquist (2014) revealed in his study that there is a potential impact regarding the use of educational robots in the elementary setting. Similarly, Khanlari (2013) revealed that robotics help students to learn STEM subjects and it has the potential to change students' understanding and to facilitate students' learning of STEM subjects. Altin and Pedaste (2013) also supported the findings through systematic literature review and concluded that robotics can be seen as a "tool" to create many approaches to STEM education such as inquiry learning and problem solving. They found that the approaches like discovery learning, collaborative learning, problem solving, project-based learning and competition-based learning have been used in educational robots. Regarding

the study of students' attitude towards educational robots, they found that it promotes students' interest in STEM subjects, which results in mitigating the lack of interest in STEM subjects in schools. Holmquist (2014) in his study suggested that there is a potential impact regarding the use of educational robots in the elementary setting and no age is too early for learning robots.

Thus, it can be concluded from these studies that as more schools embrace the STEM movement, a unified understanding and resources are needed to support teachers.

3. Objectives of The Study

The study is taken up with the following objectives in view:

1. To study the awareness of in-service teachers towards integrated STEM education.
2. To study the perception of in-service teachers towards integrated STEM education.
3. To study the attitude of in-service teachers towards integrated STEM education.

4. Research Methodology

The investigator adopted the Survey method. **Survey research** is a less structured **research methodology** used to gain in-depth information about people's underlying reasoning and motivations. The end goal is to develop a deep understanding of a topic, issue, or problem from an individual perspective.

The population of the proposed study consisted of all the ATL schools in Gujarat state i.e. 250 schools consisting of private, government and grant-in-aid schools.

SAMPLE

1. Sampling of Schools- In the whole Vadodara region, 14 schools have Atal Tinkering Labs, so it was taken as a sample. The list of schools is as follows

- a. Navrachana Vidyani Vidyalaya
- b. New Era Senior Secondary School
- c. MES Boys High School
- d. Kendriya Vidyalaya, ONGC, Vadodara
- e. MES Girls high school
- f. Zen school, padra
- g. Delhi Public School, Harni
- h. Fertilizer nagar school
- i. MES high school nagarwada
- j. Bright Day School , Bhaili
- k. Bright day School CBSE unit Vadodara
- l. Rosary High School, Vadodara
- m. Urmi School
- n. Dabhasa English School

2. Sampling of respondents- All 14 teachers in charge who are involved in managing Atal Tinkering Labs

TOOLS AND TECHNIQUES FOR DATA COLLECTION

Questionnaire: - For measuring awareness of in-service teachers for STEM education, the investigator used a questionnaire. The Questionnaire comprised of 15 questions, which were closed-ended and cov-

ered various aspects like the concept of STEM education, concept of STEM integration approach, the interdisciplinary and multidisciplinary approach, the Atal Tinkering Lab and technology used, etc. One mark was given to each correct answer, and there was no negative marking. The classification of scores of the Awareness Test shows that the scores ranging from 0-5 are put in the low awareness level category and interpreted as poor. The scores ranging from 6-11 are put in the average awareness level category and interpreted as satisfactory and the scores ranging from 12-15 are put in the high awareness level category and interpreted as good. Teachers who earn a score of 0-5, 6-11 and 12-15 are under the low, average and high awareness level categories, respectively. The questionnaire was given to STEM experts for validation.

Open-ended questions: - The perception of in-service teachers towards the STEM integration approach was measured with the help of open-ended questions. With the help of a Google form, the following questions were asked

- a. What is integrated STEM education?
- b. How does STEM influence and impact your life?
- c. Why do you think that the STEM integrated education is needed and its importance for our country?
- d. What are the barriers you face while implementing STEM in your school?

Likert Scale: - The attitude of in-service teachers towards implementation of STEM integration approach in their classrooms was measured with the help of Likert scale. Likert scale consists of a series of statements all of which are related to a person's attitude towards a single object. The scale consists of 30 items with five alternative responses. Each statement is set against a five-point scale of Strongly Agree, Agree, Undecided, Disagree and Strongly Disagree. Weightage of 5,4,3,2 and 1 were given in that order for the positive statements. The scoring is reversed for the negative statements. There were 19 positive statements and 11 negative statements. It was then validated by STEM experts. The Likert scale is given in Appendix 3.

SOURCES OF DATA:- Official documents, Principals and teachers responsible for managing ATLs

PROCEDURE FOR DATA COLLECTION

The investigator contacted ATL in charges and mailed the Google form for measuring awareness, perception and attitude regarding STEM education. The data collection procedure took at least one month.

The present study is a survey type wherein the main objective is to find awareness, perception and attitude of in-service teachers towards integrated STEM education.

The awareness of in-service teachers about integrated STEM education are collected using a questionnaire consisting of closed-ended questions and is analysed using frequency and percentage.

The perception of in-service teachers about integrated STEM education is collected using open-ended questions and is analysed using content analysis.

The attitude of in-service teachers towards integrated STEM education is collected using a Likert scale and is analysed using the Intensity Index.

5. Results and Data Analysis

LEVEL OF AWARENESS OF IN-SERVICE TEACHERS TOWARDS INTEGRATED STEM EDUCATION

To achieve objective 1 of the present study i.e. “To study the awareness of in-service teachers towards integrated STEM education” data were collected from the ATL in-charges of 14 Schools via Google Form. Data were collected through a questionnaire and collected data were analyzed using frequency and percentage which is given and analyzed in table 5.1 and table 5.2.

As shown in Table 4.1, the classification of scores of Awareness Test shows that the scores ranging from 0-5 are put in the low awareness level category and interpreted as poor. The scores ranging from 6-11 are put in the average awareness level category and interpreted as satisfactory and the scores ranging from 12-15 are put in the high awareness level category and interpreted as good. Students who earn a score of 0-5, 6-11 and 12-15 are under the low, average and high awareness level category respectively.

Table 5.1 Level of integrated STEM Awareness of the total sample

Awareness level	Range of scores	Frequency	%
High	12-15	11	78.6
Average	6-11	3	21.4
Low	0-5	0	0
Total		14	100

The score of the total sample in Table 5.1 on the level STEM awareness shows that 78.6 % of the in-service teachers are under the high score, 21.4 % are under the average score, and none of the in-service teachers are in the low score. It can be seen that majority of the in-service teachers have high level of STEM awareness and very few of the students are in the average awareness level category. This shows that STEM awareness level of in-service teachers of ATL schools in Vadodara district is good.

Table 5.2 Awareness of in-service teachers upon STEM education

Questions	No. of correct responses	No. of incorrect responses	% of correct responses
1. What does STEM stand for?	14	0	100
2. What word(s) describe STEM education?	13	1	92.9
3. Which initiative is taken by Government of India to promote a culture of innovation and entrepreneurship in the country?	14	0	100
4. ATL contains educational and learning ‘do it yourself’ kits and equipment on – science, electronics, robotics, open source microcontroller boards, sensors and 3D printers and computers.	14	0	100
5. 3D printing or additive manufacturing is a process of making three dimensional solid objects from a digital file	13	1	92.9
6. What is the full form of PLA in 3D printing technology?	7	7	50
7. Which technology is used in 3D printers in Atal Tinkering labs?	8	6	57.1

8. Who first used the acronym STEM?	10	4	71.4
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9. Which system is used for submitting Utilization Certificate in order to get subsequent tranches of grant- in –aid ?	7	7	50
10. When ATL Community Day is celebrated and to whom the tribute is given?	13	1	92.9
11. A robust STEM education creates critical thinkers, problem-solvers, and next generation innovators.	14	0	100
12. The aim of STEM education is to develop by a holistic approach by establishing a relationship between disciplines.	14	0	100
13. STEM contributes to the development of creativity in the field of engineering by using the basic knowledge and skills of individuals.	14	0	100
14. The STEM education handle children with a comprehensive concept of education (cognitive, affective and psychomotor domains), aim for children’s learning by doing and experiencing, emphasize on scientific process skills, and expect that theoretical knowledge are converted into practice.	14	0	100
15. Constructivist education approach, which is a contemporary approach, enables children to have high level thinking skills and analyze, synthesize and evaluate things at the same time.	14	0	100

The above table reveals the awareness of in-service teachers towards STEM education, Atal Tinkering Labs, technology used in STEM education etc. Almost 100 % respondents are aware of full form of STEM, concept of STEM education and the initiative taken by Government of India to promote a culture of innovation and entrepreneurship in the country through Atal Innovation Mission. Almost all the respondents (100%) are aware of Atal Tinkering Lab and all the educational and ‘Do it yourself’ kits like microcontrollers, 3D printers, sensors etc.

Only 57.1 % are aware of the technology used in 3D printers and 50 % about the most popular filament used in 3D printing. Also only half of the total respondents (50 %) are aware of the PFMS system which are used for submitting Utilization Certificate in order to get subsequent tranches of grant- in –aid.

Almost all the respondents are aware of STEM education, its aim, its contribution towards development of creativity and innovation among students and how it handles children with comprehensive concept of education i.e. all the three domains cognitive, psychomotor and affective. All the 100% respondents are aware that constructive education approach is preparatory to STEM education and it enables children to have high level thinking skills and analyze, synthesize and evaluate things at the same time.

LEVEL OF PERCEPTION OF IN-SERVICE TEACHERS TOWARDS INTEGRATED STEM EDUCATION

To achieve objective 2 of the present study i.e. “To study the perception of in-service teachers towards integrated STEM education” data were collected from the ATL in-charges of 14 Schools via Google Form. Data were collected through a questionnaire containing 4 open ended questions and collected data were qualitatively analysed using content analysis. To begin the analysis researcher read the responses and coded them according to her own schematic. The final list of codes was constructed on the basis of words, whole sentences or paragraphs and after making comparisons between the codings, categories were formed on the basis of the predominant themes and thus the coding list was simplified and its final form was determined.

The responses for question # 1 i.e. What is integrated STEM education? were straight forward and easy to code. Respondents either defined their notion of integrated STEM education, or this question was left blank. In response to research question 1, 71.4 % (10 out of 14) responded to this question and the remaining 28.6 % left that question blank. (In table 5.3)

Table 5.3 Teachers’ perception about the integrated STEM education

Category	Percent of respondents (n = 14)
Knew what integrated STEM education is	71.4 % (n= 10)
Combination of science, technology, engineering, and mathematics into one class, unit, or lesson	60% of 71.4% (n = 6)
It's a connection between subjects and real world concepts	40% of 71.4% (n = 4)
Left the question blank	28.6% (n = 4)

In response to question #2, How does STEM influence and/or impact your life? themes emerged from the survey responses that were coded into three broadly defined categories: (1) null relationship to STEM, (2) personal reasons, and (3) societal issues. Some responses fit into more than one category. Table 5.4 describes the breakdown of data into these three broad categories.

Table 5.4 Teachers’ perception about the influence of STEM education and its impact in their life

Category	% of Respondents (n = 14)
Null relationship to STEM	21.4 % (n = 3)
Personal reasons	50% (n = 7)
Social reasons	28.6 (n = 4)

CATEGORY 1- As noted in Table 5.4, 21.4 % (n = 3) felt that STEM did not impact their life, yet they were able to articulate a relevant conceptualization of it. Some typical responses in this category included the following:

Unknown.

Not at all.

Right now I have no direct contact with STEM, but would like to learn more about it.

CATEGORY 2- Of the respondents who described personal reasons as the way STEM impacted their lives, many described their own careers or discussed their children. Some typical responses in this category included the following:

It helps us to learn new and modern techniques.

It influenced me to know more about my subjects.

Since I teach Computer Science and Math, two of the four disciplines are areas I teach.

My position is partly in a technology program, and I suppose the emphasis is such that one's personal life could be improved through discoveries made through these STEM programs.

CATEGORY 3- Some responses touched on ideas that could fit into social reason categories. Exemplars from these themes include statements like:

It taught critical thinking skills and instils a passion for innovation. Beyond the benefit of learning science, technology, engineering, and math, STEM assists in the problem-solving and exploratory learning that fuel success across a variety of tasks and disciplines.

It helps to understand the concept to the children and they will be more knowledgeable. They will apply their knowledge into real life.

The initiative insures educating Indian youth in an attempt to offset the need for persons in this field to run Indian science enterprises.

In response to question # 3 it was attempted to determine their perceptions about the reasons for the necessity of STEM Education. The findings obtained as a result of the analysis of the responses given to these questions are presented in Table 5.5.

Table 5.5 Teachers' perception about the reasons for the necessity of STEM education

Category	Frequency (f)
Improvement of STEM knowledge and academic achievement	7
Skill Development	14
Affective behaviour development in STEM areas	6
Societal contribution of STEM	14
Career development in STEM areas	10

As can be seen in Table 5.5, the teachers viewed developing positive attitudes towards STEM areas, enhancing creativity and interdisciplinary inquiry skills, improvement of academic achievement and societal contribution as important reasons for the necessity of STEM education. In Skill Development category respondents mentioned different skills such as Interdisciplinary inquiry skill, interdisciplinary problem solving skill, creativity in STEM areas, technology- utilisation skill, scientific process skills and decision making skills. Teachers also responded that STEM education is necessary for people desiring a career as an Engineer or Scientist. Teachers mentioned developing positive attitudes towards STEM areas and lack of motivation as reasons for STEM education. The teachers two more reasons for the necessity of STEM education that are having a say in scientific developments and increasing the level of development of a country and they indicate that the teachers developed some ideas about the societal contribution of STEM.

In response to question # 4 it was attempted to determine teachers’ perceptions about the barriers to implementation of STEM Education. The findings obtained as a result of the analysis of the responses given to these questions are presented in Table 5.6

Table 5.6 Teachers’ perception about barriers to implementation of STEM education

Category	Code	Frequency
Teachers	The profile of teacher not open to new ideas	10
Students	Student readiness	8
Teaching Program	The content of teaching program is not suitable	11
Teacher education	Improper teacher qualifications	13
Others	Technical facilities	12
	Cost	6
	Time	10
	Difficulty in integrating the knowledge and skills of different disciplines	8
	Prejudiced Parents	2

As mentioned in above table, the biggest barrier to implementation of STEM education is improper teacher qualifications, technical facilities, time, the content or structure of teaching program and teachers not opening or accepting new ideas. Teachers also felt difficulty in integrating the knowledge and skills of different disciplines and also student’s readiness is also considered as barriers to implementation of STEM education

EFFECTIVENESS OF INTEGRATED STEM EDUCATION IN TERMS OF THE ATTITUDE OF THE IN-SERVICE TEACHERS

To achieve objective 3 of the present study i.e. “To study the attitude of in-service teachers towards integrated STEM education” data were collected from the ATL in-charges of 14 Schools via Google Form. Data were collected through a Likert type five point reaction scale. Collected data were analyzed using percentage and intensity index (II) which is given and analyzed in table 5.7.

Table 5.7 Summary of the attitude of in-service teachers towards integrated STEM education in terms of Percentage and Intensity Index (II)

S. No.	STATEMENT	SA	A	U	D	SD	II
1.	Integrated STEM education gives the scope to assess different aspects of the learner’s	42.9	57.1	0	0	0	4.4

	development.						
2.	Integrated STEM education encourages rote memorisation among the pupils	0	0	0	78.6	21.4	4.2
3.	Atal Tinkering Labs are helpful in implementing STEM education in the school.	71.4	28.6	0	0	0	4.7
4.	The stakeholders hardly play any role in the effective implementation of STEM education in the school.	0	0	7.1	78.6	14.3	4.1
5.	STEM provides opportunity to the students for greater participation in different activities of the school.	28.6	71.4	0	0	0	4.3
6.	The orientation and in-service training of teachers is essential for the proper implementation of STEM education in the school.	78.6	21.4	0	0	0	4.8
7.	STEM education does not provide a platform for the development of creative potentialities of the learners.	0	0	0	42.9	57.1	4.6
8.	Teachers feel overburdened due to introduction of integrated STEM education.	14.3	28.6	14.3	28.6	14.3	3.2

9.	Teachers owe less responsibility and accountability in the proper/effective implementation of STEM education in the school.	0	0	14.3	50	35.7	4.5
10.	STEM education provides the scope to the learner for self-evaluation.	21.4	78.6	0	0	0	4.2
11.	Implementation of STEM education could be possible without raising community awareness and appreciation.	0	0	0	78.6	21.4	4.2
12.	STEM education is helpful in assessing only cognitive domains.	0	0	14.3	71.4	14.3	4.4
13.	The child friendly climate is not an important element in STEM education.	0	0	0	71.4	28.6	4.3
14.	Government is helping in implementing STEM education by establishing Atal Tinkering Labs in both urban and rural schools.	78.6	21.4	0	0	0	4.8
15.	For effective implementation of STEM education, the resource materials need to be provided to all the schools for ready reference by the teachers.	64.3	28.6	0	0	0	4.5
16.	Development of the thought process of the learners is given more emphasis in STEM education.	50	50	0	0	0	4.5
17.	Teachers need to be trained in STEM education before its introduction in the school.	85.7	14.3	0	0	0	4.8
18.	For the effective implementation of STEM, the teacher's manual shall be provided for practical guidance.	64.3	35.7	0	0	0	4.6
19.	STEM education never gives opportunity to the learners for self-evaluation.	0	0	0	85.7	14.3	4.1
20.	Successful implementation of STEM education in the school requires a strong and supportive monitoring mechanism.	64.3	35.7	0	0	0	4.6
21.	A robust STEM education creates critical thinkers, problem-solvers, and next generation innovators.	57.1	42.9	0	0	0	4.6

22.	Robotics impacts the students' interests and achievements in STEM related subjects in negative way.	0	0	0	57.1	42.9	4.4
23.	Robotics, with its multi-disciplinary nature, provides constructive learning environments that are suitable for a better understanding of more scientific and non-scientific subjects and it has a significant role on learning Mathematics, Science, Technology, and Engineering subjects.	57.1	42.9	0	0	0	4.6
24.	The plug-and-play characteristic of educational robots, like LEGO Mindstorm RCX, makes it easier to learn complex engineering subjects without having prerequisite knowledge.	14.3	78.6	7.1	0	0	4.1
25.	Robotics in STEM education increases students' self-confidence and this self-confidence leads students to try more and be better in other courses.	50	50	0	0	0	4.5
26.	The Schools in Vadodara understand the importance of STEM education.	0	57.1	42.9	0	0	3.6
27.	There are colleges and/or universities and/or community colleges that offer scholarships for students to pursue STEM degrees in Vadodara.	0	0	42.9	50	7.1	2.6
28.	My school organises STEM related training programmes for teachers.	0	71.4	14.3	7.1	7.1	3.5
29.	My School allows teachers to participate in STEM workshops and training programs.	7.1	78.6	14.3	0	0	4.1
30.	The Constructivist Education Approach is preparatory to the STEM education	57.1	42.9	0	0	0	4.6
OVERALL REACTION							4.54

In terms of the attitude of in-service teachers towards statement 1 i.e. "Integrated STEM education gives the scope to assess different aspects of the learner's development.", 42.9 per cent and 52.1 per cent of them reacted as strongly agree and agree, respectively. The intensity index of 4.4 showed a favourable

attitude of in-service teachers towards integrated STEM education stating that it gives the scope to assess different aspects of learner's development.

In terms of the attitude of in-service teachers towards statement 2 i.e. "Integrated STEM education encourages rote memorisation among the pupils.", 78.6 per cent and 21.4 per cent of them reacted as disagree and strongly disagree respectively. The intensity index of 4.2 showed favourable attitude of in-service teachers towards integrated STEM education stating that it actually discourages rote memorisation among the students.

In terms of the attitude of in-service teachers towards statement 3 i.e. "Atal Tinkering Labs are helpful in implementing STEM education in the school.", 71.4 per cent and 28.6 per cent of them reacted as strongly agree and agree respectively. The intensity index of 4.7 showed strongly favourable attitude of in-service teachers towards integrated STEM education stating that Atal Tinkering Labs in schools are helpful in implementing STEM education.

In terms of the attitude of in-service teachers towards statement 4 i.e. "The stakeholders hardly play any role in the effective implementation of STEM education in the school.", 7.1 per cent, 78.6 percentage and 14.3 per cent of them reacted as undecided, disagree and strongly disagree respectively. The intensity index of 4.1 showed favourable attitude of in-service teachers towards integrated STEM education stating that the stakeholders play very important role in the effective implementation of STEM education in the school.

In terms of the attitude of in-service teachers towards statement 5 i.e. "STEM provides opportunity to the students for greater participation in different activities of the school.", 28.6 percentage and 71.4 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.3 showed favourable attitude of in-service teachers towards integrated STEM education stating that STEM provides opportunity to students to participate in different activities of the school

In terms of the attitude of in-service teachers towards statement 6 i.e. "The orientation and in-service training of teachers is essential for the proper implementation of STEM education in the school.", 78.6 percentage and 21.4 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.8 showed strongly favourable attitude of in-service teachers towards integrated STEM education stating that for successful implementation of STEM education in school the orientation and in-service training of teachers are very important.

In terms of the attitude of in-service teachers towards statement 7 i.e. "STEM education does not provide a platform for the development of creative potentialities of the learners", 42.9 percentage and 57.1 percentage of them reacted as disagree and strongly disagree respectively. The intensity index of 4.6 showed strongly favourable attitude of in-service teachers towards integrated STEM education stating that STEM education provides a strong platform for the development of creative potentialities of the learners.

In terms of the attitude of in-service teachers towards statement 8 i.e. "Teachers feel overburdened due to introduction of integrated STEM education", 14.3 percentage, 28.6 percentage, 14.3 percentage, 28.6 percentage and 14.3 percentage of them reacted as strongly agree, agree, undecided, disagree and strongly disagree respectively. The intensity index of 3.2 showed moderate attitude of in-service teachers towards overburdening of teachers due to introduction of integrated STEM education. Some felt overburdened whereas few of them felt it as the part of their job and it actually helps them to make students understand the difficult concepts.

In terms of the attitude of in-service teachers towards statement 9 i.e. “Teachers owe less responsibility and accountability in the proper/effective implementation of STEM education in the school”, 14.3 percentage, 50 percentage and 35.7 percentage of them reacted as undecided, disagree and strongly disagree respectively. The intensity index of 4.5 showed strongly favourable attitude of in-service teachers towards integrated STEM education stating that Teachers have lot of responsibility and accountability in the proper/ effective implementation of STEM education in the school.

In terms of the attitude of in-service teachers towards statement 10 i.e. “STEM education provides the scope to the learner for self-evaluation.”, 21.4 per cent and 78.6 per cent of them reacted as strongly agree and agree respectively. The intensity index of 4.2 showed favourable attitude of in-service teachers towards integrated STEM education stating that it provides the scope to the learner for self-evaluation.

In terms of the attitude of in-service teachers towards statement 11 i.e. “Implementation of STEM education could be possible without raising community awareness and appreciation”, 78.6 percentage and 21.4 percentage of them reacted as disagree and strongly disagree respectively. The intensity index of 4.2 showed favourable attitude of in-service teachers towards integrated STEM education stating that implementation of STEM education in schools requires community awareness and appreciation.

In terms of the attitude of in-service teachers towards statement 12 i.e. “STEM education is helpful in assessing only cognitive domains.”, 14.3 percentage, 71.4 percentage and 14.3 percentage of them reacted as undecided, disagree and strongly disagree respectively. The intensity index of 4.4 showed favourable attitude of in-service teachers towards integrated STEM education stating that STEM education is helpful in assessing not only the cognitive domain but also the affective and psychomotor domains.

In terms of the attitude of in-service teachers towards statement 13 i.e. “The child friendly climate is not an important element in STEM education.”, 71.4 per cent and 28.6 per cent of them reacted as disagree and strongly disagree, respectively. The intensity index of 4.3 showed a favourable attitude of in-service teachers towards integrated STEM education stating that it is a student- centred approach.

In terms of the attitude of in-service teachers towards statement 14 i.e. “Government is helping in implementing STEM education by establishing Atal Tinkering Labs in both urban and rural schools.”, 78.6 percentage and 21.4 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.8 showed strongly favourable attitude of in-service teachers towards the help provided by Government in implementing STEM education by establishing Atal Tinkering Labs in both urban and rural schools.

In terms of the attitude of in-service teachers towards statement 15 i.e. “For effective implementation of STEM education, the resource materials need to be provided to all the schools for ready reference by the teachers.”, 64.3 percentage and 28.6 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.5 showed strongly favourable attitude of in-service teachers towards the necessity of resource materials for effective implementation of STEM education.

In terms of the attitude of in-service teachers towards statement 16 i.e. “Development of the thought process of the learners is given more emphasis in STEM education.”, 50 percentage and 50 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.5 showed strongly favourable attitude of in-service teachers towards integrated STEM education stating that it emphasizes on development of the thought process of the learners as it is student- centered approach.

In terms of the attitude of in-service teachers towards statement 17 i.e. “Teachers need to be trained in STEM education before its introduction in the school.”, 85.7 percentage and 14.3 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.8 showed strongly favourable attitude of in-service teachers towards the necessity of training of teachers in STEM education before its introduction in the school.

In terms of the attitude of in-service teachers towards statement 18 i.e. “For the effective implementation of STEM, the teacher’s manual shall be provided for practical guidance.”, 64.3 percentage and 35.7 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.6 showed strongly favourable attitude of in-service teachers towards the importance of teacher’s manual for practical guidance for effective implementation of STEM education.

In terms of the attitude of in-service teachers towards statement 19 i.e. “STEM education never gives opportunity to the learners for self-evaluation.”, 85.7 percentage and 14.3 percentage of them reacted as disagree and strongly disagree respectively. The intensity index of 4.1 showed favourable attitude of in-service teachers towards the integrated STEM education as it gives opportunity to the learners for self-evaluation.

In terms of the attitude of in-service teachers towards statement 20 i.e. “Successful implementation of STEM education in the school requires a strong and supportive monitoring mechanism.”, 64.3 percentage and 35.7 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.6 showed strongly favourable attitude of in-service teachers towards the necessity strong and supportive monitoring mechanism for effective implementation of STEM education.

In terms of the attitude of in-service teachers towards statement 21 i.e. “A robust STEM education creates critical thinkers, problem-solvers, and next generation innovators.”, 57.1 percentage and 42.9 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.6 showed strongly favourable attitude of in-service teachers towards the integrated STEM education as it encourages critical thinking, problem- solving attitude in students and create next generation innovators.

In terms of the attitude of in-service teachers towards statement 22 i.e. “Robotics impacts the students’ interests and achievements in STEM related subjects in negative way.”, 57.1 percentage and 42.9 percentage of them reacted as disagree and strongly disagree respectively. The intensity index of 4.4 showed favourable attitude of in-service teachers towards the Robotics in STEM education as it impacts the students’ interests and achievements in positive way.

In terms of the attitude of in-service teachers towards statement 23 i.e. “Robotics, with its multi-disciplinary nature, provides constructive learning environments that are suitable for a better understanding of more scientific and non-scientific subjects and it has a significant role on learning Mathematics, Science, Technology, and Engineering subjects.”, 57.1 percentage and 42.9 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.6 showed strongly favourable attitude of in-service teachers towards the Robotics in STEM education and its multi-disciplinary nature.

In terms of the attitude of in-service teachers towards statement 24 i.e. “The plug-and-play characteristic of educational robots, like LEGO Mindstorm RCX, makes it easier to learn complex engineering subjects without having prerequisite knowledge.”, 14.3 percentage, 78.6 percentage and 7.1 percentage of them reacted as strongly agree, agree and undecided respectively. The intensity index of 4.1 showed favourable attitude of in-service teachers towards the plug and play characteristic of educational robots which makes easier to learn complex topics or subjects like engineering.

In terms of the attitude of in-service teachers towards statement 25 i.e. “Robotics in STEM education increases students’ self-confidence and this self-confidence leads students to try more and be better in other courses.”, 50 percentage and 50 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.5 showed strongly favourable attitude of in-service teachers towards the necessity of Robotics in STEM education which increases students’ self-confidence which leads to perform better in other courses.

In terms of the attitude of in-service teachers towards statement 26 i.e. “The Schools in Vadodara understand the importance of STEM education.”, 57.1 percentage and 42.9 percentage of them reacted as agree and undecided respectively. The intensity index of 3.6 showed favourable attitude of in-service teachers towards understanding the importance of STEM education by the schools in Vadodara.

In terms of the attitude of in-service teachers towards statement 27 i.e. “There are colleges and/or universities and/or community colleges that offer scholarships for students to pursue STEM degrees in Vadodara.”, 42.9 percentage, 50 percentage and 7.1 percentage of them reacted as undecided, disagree and strongly disagree respectively. The intensity index of 2.6 showed not favourable attitude of in-service teachers towards the scholarships provided by colleges or universities in order to pursue STEM degrees in Vadodara.

In terms of the attitude of in-service teachers towards statement 28 i.e. “My school organises STEM related training programmes for teachers.”, 71.4 percentage, 14.3 percentage, 7.1 percentage and 7.1 percentage of them reacted as agree, undecided, disagree and strongly disagree respectively. The intensity index of 3.5 showed moderately favourable attitude of in-service teachers towards the organisation of STEM related training programmes for teachers by the school.

In terms of the attitude of in-service teachers towards statement 29 i.e. “My School allows teachers to participate in STEM workshops and training programs.”, 7.1 percentage, 78.6 percentage and 14.3 percentage of them reacted as strongly agree, agree and undecided respectively. The intensity index of 4.1 showed favourable attitude of in-service teachers towards the permission given by schools to the teachers to participate in STEM related workshops and training programs.

In terms of the attitude of in-service teachers towards statement 30 i.e. “The Constructivist Education Approach is preparatory to the STEM education”, 57.1 percentage and 42.9 percentage of them reacted as strongly agree and agree respectively. The intensity index of 4.6 showed strongly favourable attitude of in-service teachers towards the Constructivist approach being the foundation or preparatory to the STEM education.

MAJOR FINDINGS OF THE STUDY

Objective 1- To study the awareness of in-service teachers towards integrated STEM education

- Majority of in-service teachers in the sample are ATL- incharges of their schools.
- Majority of in-service teachers are aware of the full form of STEM and concept of STEM education.
- Majority of in-service teachers are aware of Atal Tinkering Lab and all the educational and DIY kits like microcontrollers, sensors, 3D printers etc.
- Only half of the in-service teachers are aware of technology used in 3D printer and the most popular filament used in 3D printer i.e. Polylactic Acid.
- Only half of the in-service teachers are aware of Public financial management System (PFMS) which they use for submitting Utilization Certificate in order to get subsequent tranches of grant-in-aid.
- Majority of in-service teachers are aware of STEM education, its aim, its contribution towards development of creativity and innovation among students and how it handles children with comprehen-

sive concept of education i.e. all the three domains cognitive, psychomotor and affective.

- All the respondents are aware of constructive education being the preparatory of STEM education.

Objective 2- To study the perception of in-service teachers towards integrated STEM education

- 71.4% in-service teachers knew what integrated STEM education is. Their perception is positive towards the integrated STEM education
- In response to perception towards how STEM education impacted their life, half of the in-service teachers (50%) gave personal reasons like how STEM education modified their way of teaching and how it helps in enhancing their subject knowledge. Few of them gave social reasons and rest of them mentioned null relationship with STEM.
- In response to perception about the reasons for the necessity of STEM education the teachers viewed developing positive attitudes towards STEM areas, enhancing creativity and interdisciplinary inquiry skills, improvement of academic achievement and societal contribution as important reasons for the necessity of STEM.
- In response to perception about barriers to implementation of STEM education the in-service teachers mentioned the biggest barrier to implementation of STEM education is improper teacher qualifications, technical facilities, time, the content or structure of teaching program and teachers not opening or accepting new ideas.

Objective 3- To study the attitude of in-service teachers towards integrated STEM education

- Majority of in-service teachers showed favourable attitude towards integrated STEM education stating that it gives the scope to assess different aspects of learner's development.
- Majority of in-service teachers showed favourable attitude towards integrated STEM education stating that it actually discourages rote memorisation among the students.
- Majority of in-service teachers showed strongly favourable attitude towards that Atal Tinkering Labs in schools which are helpful in implementing STEM education
- Majority of in-service teachers showed favourable attitude towards integrated STEM education stating that the stakeholders play very important role in the effective implementation of STEM education in the school.
- Majority of in-service teachers showed favourable attitude towards STEM education which provides opportunity to students to participate in different activities of the school.
- Majority of in-service teachers showed strongly favourable attitude towards integrated STEM education stating that for successful implementation of STEM education in school the orientation and in-service training of teachers are very important.
- Majority of in-service teachers showed strongly favourable attitude towards STEM education which provides a strong platform for the development of creative potentialities of the learners.
- Majority of in-service teachers showed moderate attitude towards overburdening of teachers due to introduction of integrated STEM education. Some felt overburdened whereas few of them felt it as the part of their job and it actually helps them to make students understand the difficult concepts.
- Majority of in-service teachers showed strongly favourable attitude towards integrated STEM education stating that Teachers have lot of responsibility and accountability in the proper/ effective implementation of STEM education in the school.
- Majority of in-service teachers showed favourable attitude towards integrated STEM education stating that STEM education is helpful in assessing not only the cognitive domain but also the affective

and psychomotor domains.

- Majority of in-service teachers showed favourable attitude towards integrated STEM education stating that it is a student- centred approach.
- Majority of in-service teachers showed favourable attitude towards STEM education which provides opportunity to students to participate in different activities of the school.
- Majority of in-service teachers showed strongly favourable attitude towards the help provided by Government in implementing STEM education by establishing Atal Tinkering Labs in both urban and rural schools.
- Majority of in-service teachers showed strongly favourable attitude towards the necessity of resource materials for effective implementation of STEM education.
- Majority of in-service teachers showed strongly favourable attitude towards the necessity of training of teachers in STEM education before its introduction in the school.
- Majority of in-service teachers showed strongly favourable attitude towards the importance of teacher's manual for practical guidance for effective implementation of STEM education.
- Majority of in-service teachers showed strongly favourable attitude towards the necessity strong and supportive monitoring mechanism for effective implementation of STEM education.
- Majority of in-service teachers showed strongly favourable attitude towards the integrated STEM education as it encourages critical thinking, problem- solving attitude in students and create next generation innovators.
- Majority of in-service teachers showed favourable attitude towards the Robotics in STEM education as it impacts the students' interests and achievements in positive way.
- Majority of in-service teachers showed strongly favourable attitude towards the Robotics in STEM education and its multi-disciplinary nature.
- Majority of in-service teachers showed favourable attitude towards the plug and play characteristic of educational robots which makes easier to learn complex topics or subjects like engineering.
- Majority of in-service teachers showed moderately favourable attitude towards the organisation of STEM related training programmes for teachers by the school.
- Majority of in-service teachers showed favourable attitude towards the permission given by schools to the teachers to participate in STEM related workshops and training programs.
- Majority of in-service teachers showed strongly favourable attitude towards the Constructivist approach being the foundation or preparatory to the STEM education.

6. Discussion

It was observed that in-service teachers which are also ATL-incharges of their school had positive perceptions on STEM education. According to the teachers, STEM education brings an individual in problem solving skill, arouses an individual's interest in the course and enhances his motivation, enables him to be technological literate and to have creative and critical thinking skills by putting forth different projects. As Breiner (2012) argued, children take part in different projects by STEM education, use many technologies in this project training process and this enhances their motivations. Children whose motivations enhance become open to new information and skills. What is important is to continue these skills for the whole life. Because the world we live in changes swiftly. It seems difficult especially for young children and teachers to follow these changes and adapt. Here STEM is an education that helps

children and teacher in both children's planning their developmental characteristics and teacher's planning the learning-teaching process in the classroom and how they should use technology.

Children make inventions like a researcher in STEM education and converts their knowledge on different disciplines such as Science, Technology, Engineering and Mathematics to practice (Esra Bozkurt Alan, 2016). Therefore, there is not a single expected outcome of the system in STEM education. Children entering the system gain knowledge and skills with a comprehensive education approach throughout the process. Thus, also in this research, in-service teachers opined similarly to these explanations made on STEM education. It was observed that teachers expressed positive attitude towards STEM education that it provides life skills to children, children handle real life problems and find solutions by STEM and it provides children self-respect, empathy and many other skills.

It can be recommended that in-service training programs should be developed for teachers to raise their awareness of the necessity of STEM education and to enhance their competencies in planning, implementation and evaluation of an instructional process suitable for this approach.

7. Conclusion

The present study was conducted with the objective to study awareness, perception and attitude of in-service teachers towards integrated STEM education. The findings of this study revealed that the majority of teachers are aware of the concept of STEM education, government initiatives towards STEM education in the form of Atal Tinkering Labs, the educational kits used in these labs. But few teachers also need to brush up on their knowledge about the technologies used in these labs for implementing STEM education. The study also revealed the perception of in-service teachers towards the necessity of STEM education, how it affects their lives, and the barriers they faced while implementing STEM education in their schools. The majority of in-service teachers showed a favourable attitude towards STEM education and how it can be integrated in the school curriculum.

8. Educational Implications

The following are the implications drawn out from the findings of the present study:

The findings can give suggestions to government and non-government organizations to frame and conduct professional development programmes for in-service teachers with the aim to enhance technological knowledge and 21st century skills used in implementing STEM education in their classes. The curriculum of pre-service teacher education programmes should be designed with the objective to develop passion towards STEM education so that teachers are motivated to implement innovative teaching methods in the classrooms.

9. Suggestions For Further Studies

- STEM education and constructivist education approach can be compared for further studies.
- Comparison of STEM education with different approaches/models and theories can be made.
- Contributions of teaching programs prepared according to STEM education on individuals' high level thinking skills can be investigated.
- Qualitative and quantitative studies can be conducted on student profiles in schools in which STEM education is applied.

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