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Is Robotics Education and Training Gender Dependent? A Suggestive Robotics Syllabus for Teacher Training

G S Prakasha*, Joseph Varghese Kureethara,
Anthony Kenneth and Peter Varkey Muttungal
Christ University, Bangalore, India
https://orcid.org/0000-0002-1287-7606
https://orcid.org/0000-0001-5030-3948
https://orcid.org/0000-0001-7798-2389
https://orcid.org/0000-0002-1953-3830

Trent Grundmeyer
Drake University, Des Moines, Iowa, USA
https://orcid.org/0000-0002-0747-2276

Abstract. Application of robotics is rapidly increasing in all fields of life. Though robotics education became popular in the 21st century, its teaching and training has not gained much importance across the world, especially in developing and low-income countries. There are various reasons for its neglect and one of them could be gender-science stereotypes. Research studies are yet to explore the reasons for its slow emergence. The present study explores the need and training for educational robotics considering the role of students, teachers, teacher-educators and parents, determining whether it is gender-dependent or not. The study also proposes to come up with a syllabus for robotics training. The study employs exploratory, sequential, qualitative-quantitative mixed-method research design and applies purposive sampling techniques. Researchers conducted semi-structured interviews, including five science teacher-educators, five science teachers, and five trainee teachers majoring in sciences to understand the need, scope and benefits of robotics education. They recruited 100 high school students, 50 teacher-educators, and 100 parents to test whether their interest in robotics is gender-dependent through Chi-square analysis. The study revealed the need for robotics education under four themes and seven subthemes. It has been found that the interest of students and parents and the readiness of teacher-educators for robotics education is gender-dependent. The study came up with a suggestive syllabus for robotics training. It recommends that future

* Corresponding author: *G S Prakasha, prakasha.gs@christuniversity.in*

researchers should focus on the implementation of robotics teaching for teacher and school education.

Keywords: educational robotics; robotics training; robotics syllabus; gender-science stereotype

1. Introduction

Educational robotics is a modern pedagogical tool to be included in teaching and learning. 21st century learners need to learn high quality science, technology, engineering, and mathematics (STEM). As technology advances, the products resulting from such advancement permeates educational fields and students would use them in the learning process, from elementary to higher education (Casey et al., 2018). Robotics education promotes students' interest in STEM subjects (Khanlari, 2013). It is also conceived as a branch, which deals with educating students to create and design robots (Vicente et al., 2021). The primary aim is the ability to create robots via programming and adding various functional responses. Students use a robotics kit, which is appropriate to their age (Vega & Cañas, 2018). The subject is a notable means to promote academic achievements in the field of STEM (Afari & Khine, 2017) and STEAM (Science, Technology, Engineering, Arts and Mathematics) subjects (Hinojo-Lucena et al., 2020). Robotics education can promote aconstructivist classroom learning and create an active learning environment (Barak & Assal, 2018). In addition, it can be used to promote skills such as: creativity and spatial memory skills, psychomotor skills (Alemi et al., 2020), collaborative learning (Chootongchai et al., 2019), creativity (Yi, 2019), entrepreneurship (Blackley & Howell, 2019), and project-based learning skills (Caballero-González & García-Valcárcel, 2020).

2. Review of Literature

A study on the attitude of students towards robotics found that girls have less robotics learning desire and confidence than boys (Kucuk & Sisman, 2020). Another study by Sullivan showed that robotics teaching in K-12 education enhances scientific knowledge among students (Sullivan, 2008).The use of robotics in primary education has significantly increased students' confidence and interest in science and technology (Zviel-Girshin et al., 2020). A study by Karypi (2018) showed that robotics education develops a positive attitude towards STEM and boosts cognitive and social skills of learners, making them more independent, active, and motivated. Another study by Tsagaris et al. (2019) indicated that participants are happier and more satisfied in learning science and other school subjects via robotics rather than through conventional methods. They learn to cooperate and enjoy learning through playing with robotics.

Robotics education is emerging as a pedagogical approach to science teaching. A systematic review related to applying robotics in school education clearly articulated the presence of robotics in western education since 2000 (Kubilinskiene et al., 2017). Teacher education must emphasise the need for educational robotics training, and train future teachers to incorporate multi-platform-approaches in robotics teaching (Boyarinov & Samarina, 2020) and design approach to promote easy learning. Educational robotics activities are easier to use when programmed based on behaviour-based approach (De Cristoforis et al., 2013). Studies have shown the need for robotics in higher education and termed them as an "innovative approach' towards teaching subjects like sciences and engineering (Sánchez et al., 2019). A study by Gorakhnath and Padmanabhan (2017) on educational robotics introduced educational robotics teaching and learning, leading to an understanding of the teacher's engagement.

The gender stereotype has existed in vocational choices since the last two to three decades and will remain persistent (OECD, 2017). The global gender gap report from the World Economic Forum confirms the underrepresentation of women in STEM fields (WEF, 2017). Gender stereotypes believe that women are born to pursue humanities and men should study technical fields (Charles & Bradley, 2009). Indian women too are dropping out from STEM education and careers for various indigenous reasons (Hammond et al., 2020). A study asked pre-service teachers to teach primary school children with robotics and technology. It revealed that teachers gained confidence and knowledge, which helped them to integrate technology in their classrooms (Chalmers et al., 2012).

3. Theoretical Framework

Theoretical frameworks that guided the present study include Social Identity Theory (SIT) and Social Role Theory (SRT). The central idea of the social identity theoretical framework is that people compare themselves by forming in-groups (us) and out-groups (them) to enhance their self-image (Tajfel & Turner, 1979). This involves three-stage mental processes in the order of social categorisation, social identification, and social comparison. In social categorisation, people group themselves in order to understand the social environment. In social identification, humans adopt the identity of the group they belong to and in social comparison, they compare their own with other groups and try to maintain self-esteem on par with others. Similarly, in the present study, students, teachers, teacher-educators and parents have an implicit understanding of the group they belong to and process their behaviour accordingly. Consequently, gender-science stereotypes are evident. The social role theory suggests that the gender role is visible every day. People observe the roles of men and women and thereby form their own beliefs leading to gender stereotypes (Eagly & Wood, 2012).

4. Context of the Study

In India, robotics education is a value-added programme in school education rather than a part of the school's curriculum. One gets use to see robotics in science exhibitions, science fairs, science competition, science club events, and in engineering education, but not in the school's curriculum, bearing in mind that teachers have no training to complement their classes with educational robotics pedagogy. In spite of several research studies on robotics as a pedagogy of science teaching, it is missing in mainstream school education. Teacher preparation colleges never attempted to include robotics training in their curriculum. Govinda, (2020), while emphasising STEM education, did mention the need for robotics teaching and training at all levels.

Though robotics has been in India since a decade, there are not many serious discussions to utilise its benefits for science education. This could have several reasons, such as traditional Indian culture, non-materialistic value systems, huge population, financial deficit, educational infrastructure, and lack of awareness and human resources. India has the highest youth population and investments in robotics education would have been productive. Additionally, there are facts such as female literacy rate being lower than male. There is also a gender-science stereotype belief. There are more number of female teachers than male. As men opt for professions other than teaching, there are more female science teacher educators than male. There is also less representation of women in the field of science, STEM education, and engineering as in many other countries (Gupta, 2019). Some of the reasons for this include family decisions, economic issues, gender stereotypes, social differences, social expectations, male domination, and lack of role models (Gupta, 2019; Wang & Degol, 2017).

Therefore, the present study attempts to understand low representation of women in science education, more female representation as science teachers and science teacher-educators and women as parents affecting the prevalence, acceptance, and emergence of robotics education. There is a need for proper planning of robotics education, how it could be included, what content can be included, who will teach, and what kind of training is needed for pre-service and in-service teachers. Schools in India, which recognised the value of robotics education, have added it as an optional value-added programme. But a huge number of schools still lack awareness of robotics education and teachers too lack training. Therefore, the present study aims to:

- Explore the need, importance, benefits, and training of educational robotics;
- Test whether high school students' interest, teacher-educators' readiness, and parents' interest in robotics education is gender-dependent or not; and
- Frame a syllabus including theory and practicum to train teacher trainees majoring in sciences in the teacher education programme.

5. Methods

The study employed an exploratory, sequential, qualitative-quantitative mixed method research design to address the research objectives that were framed. Researchers obtained institutional, ethical clearance and followed all the necessary ethical guidelines during each type of data collection.

5.1. Qualitative Method

5.1.1. Research Design

To explore the need, importance, benefits, and training of educational robotics, the study employed phenomenological interpretative research design.

5.1.2. Participants

The study used convenient sampling techniques and selected 15 participants for the interview - five science teacher educators, five teacher-trainees majoring in sciences at the Bachelor of Education program, and five in-service science teachers at secondary schools. The researchers assigned pseudonyms to the participants as P1, P2… and P15. Table 1 presents the demographic characteristics of the interviewees.

Table 1: Showing the demographic details of the participants

Sl. No	Designation	Age	Gender	Teaching/learning subject
P1	Teacher Educator	40	M	Physics
P2	Teacher Educator	42	M	Chemistry
P3	Teacher Educator	35	M	Biology
P4	Teacher Educator	38	F	Mathematics
P5	Teacher Educator	52	F	Physics
P6	Teacher trainee	25	M	Physics
P7	Teacher trainee	28	M	Chemistry
P8	Teacher trainee	30	M	Biology
P9	Teacher trainee	26	F	Mathematics
P10	Teacher trainee	29	F	Physics
P11	School teacher	25	M	Science
P12	School teacher	30	M	Science
P13	School teacher	35	M	Science
P14	School teacher	32	F	Science
P15	School teacher	38	F	Science

5.1.3. Interview Guide

The researchers developed a semi-structured interview guide as per the objective of the study and validated it with a panel of experts, involving senior professors from three reputed universities. Table 2 presents the interview guide used for the study.

Table 2: Interview guide

Questions for teacher educators

- Why do you think robotics education is important for STEM education?
- Should teacher education programs preparing science teachers have training in educational robotics? Explain
- What are the other benefits of educational robotics?
- Why do you think there is a need for robotics labs in teacher education programme?

Questions for secondary school teachers

- Why do you think robotics education is important for STEM education?
- Should teacher education programmes preparing science teachers have training in educational robotics? Explain
- What are the other benefits of educational robotics?
- Why do you think there is a need for robotics labs in schools?

Questions for secondary school teacher trainees majoring in sciences

- Why do you think robotics education is important for STEM education?
- Should teacher education programmes preparing science teachers have training in educational robotics? Explain
- What are the other benefits of educational robotics?
- Why do you think there is a need for robotics labs in a teacher education programme?

5.1.4. Data Gathering Procedure

One of the authors of the study, who holds a PhD in education and has 20 years of experience, conducted the interviews via online video-conferencing platforms such as Cisco WebEx/ Google Meet, while a few were telephonic. At the beginning of each interview, the researcher explained the purpose of the study and obtained consent from participants. The researchers gave participants the privilege to withdraw from the interview at any point of time if they were not comfortable. The researchers assured the participants of anonymity, safety, and confidentiality of data. They conducted semi-structured interviews with a funnelling approach to understand the need for robotics education. The funnelling approach helped the researchers to elicit in-depth information. Interview recordings and transcripts were stored safely with password protection and are available only to researchers.

5.1.5. Data Analysis Procedure

Researchers read and re-read the transcripts several times to carry out inductive analysis of the data. Consensus from all the researchers have evolved with major themes and subordinate themes (Marshall, 1999) presented in Table 4 of the result section. The Figure 1 below shows the inductive analysis coding process used in the study and is adapted from Creswell (2002).

Initial reading of the transcripts	**Identifying specific part of the transcripts**	**Labelling and creating categories**	**Refining the categories**	**Creating models with major themes and subthemes**
Full text	Part of the text	15 categories emerged	Retained 8 categories	4 major themes and 7 sub-themes

Figure 1: Showing the inductive analysis coding process

5.2. Quantitative Method

5.2.1. Research Design

To test whether the high school students' interest, teacher educators' readiness and parents' interest in robotics education is gender dependent or not, the study employed descriptive survey research design.

5.2.2. Research Informants

Researchers observed that many schools in India have recently started robotics coaching as an extra-curricular activity, while some schools are still planning it. One researcher adopted purposive sampling techniques and selected a school, which is starting robotics coaching. He selected 50 males, 50 females and their parents. To obtain the opinions of teacher educators, the study used snowball-sampling method and selected 25 male and 25 female teacher educators of science pedagogy in teacher education colleges across the country.

5.2.3. Survey Instrument

The researcher constructed a dichotomous response type opinionnaire, which included a consent form, demographic information and opinion statements. The study established face and content validity of the opinionnaire with a panel of experts. Table 3 below displays the items of the opinionnaire.

Table 3: Survey opinionnaire

Demographic details: Gender – Male /Female		
Items	**Dichotomous response**	
Student: Are you interested in the robotics coaching that your school is going to start	Yes	No
Parent: Are you admitting your child to robotics education coaching, which the school is going to start	Yes	No
Teacher educator: Are you ready to train your teacher trainees through robotics pedagogy if robotics theory and practicum are included in the syllabus	Yes	No

5.2.4. Data Collection Procedure

The researcher collected the opinion of 50males and 50 females about their interest in robotics education and recorded their responses. The investigator also collected the opinions of their parents related to their interest in enrolling their children to robotics coaching at school. There were 100 parents altogether, with equal representation by male and female parents. In order to maintain the objectivity of data and to avoid bias, parent's responses were kept confidential and did not disclose anything to the child or the partner parent. The researcher also collected the opinions of 50 teacher educators (25 males and 25 females) using convenient sampling on their readiness to train science teacher trainees through robotics. The study analysed the collected data using Chi-square test of association. It helps in confirming the observed relationship with respect to the expected relationship. Chi-square test of independence is suitable, as there are two dichotomous variables - gender and interest/investment in robotics education.

In order to address the third research objective, researchers planned to construct a syllabus unit including fundamental concepts on robotics and its practicum. The syllabus must help to initiate robotics education and training in teacher training programmes. It could be a part of science elective syllabus to train teacher trainees majoring in sciences. Researchers developed a draft syllabus and checked it for its face and content validity. One of the researchers facilitated the inter-rater reliability process of the constructed syllabus. The facilitating researcher employed a snowball sampling technique to select the panel of subject experts for inter-rater reliability analysis. The facilitating researcher in consultation with other researchers selected 20 expert teacher educators involved in preparing science teachers at teacher education colleges. The researchers briefed the panel about the research purpose, circulated the draft syllabus to the expert panel members and obtained their agreement and suggestions against each content item of the proposed syllabus, using a rating scale ranging from one to ten points. The inter-rater reliability statistics have been applied to find the reliability of the constructed syllabus. Table 11 in the result section presents the result of reliability statistics. The final draft of the syllabus incorporated the suggestions provided by the experts (Mahajan et al., 1976). Appendix1 presents the final framed syllabus and practicum.

6. Results and Discussion
6.1. Results of Qualitative Analysis
Table 4 below represents the themes and subthemes evolved out of inductive analysis of the semi-structured interview data, addressing the need and importance of robotics education and training.

Table 4: Showing the themes and subthemes

1. Robotics education a. Importance b. Scope 2. Robotics training a. Unexplored 3. Benefits of robotics education a. Quality science education b. Innovation 4. Robotics lab a. Investment b. Practicum training

This section discusses the essential features of the main theme and subtheme evolved out of the inductive analysis method from the interview transcripts of teacher educators, teacher trainees and teachers. The essential features involved the meaning of themes and subthemes, key characteristics, text samples, and review supports.

Main Theme 1: Robotics Education
Science, Technology, Engineering, and Mathematics (STEM) education has gained importance all over the world in the last two decades. Robotics change the way students learn STEM subjects and make them more knowledgeable and well-adjusted. Robotics attracts students to STEM education and brings fun, enjoyment, and satisfaction in learning. It captures student attention and interest and provides satisfying learning experiences (Eguchi, 2010).

a) Subtheme: Importance
Teacher educators, teacher trainees, and science teachers have unanimously mentioned that robotics is the future pedagogy for STEM education. It brings variety to the classroom and engages students actively in science learning. It encourages innovation and critical thinking. It also develops problem-solving ability.

P1 – […] Robotics boosts students' interest in sciences…
P13 - […] it brings innovation…

b) Subtheme: Scope
As technology advances, the use of robotics increases in all occupations. Students learn through the play-way method. It helps learners to understand abstract science concepts. It utilises both cognitive and social constructivist

approaches, and enhances the computational thinking of students, which is necessary for a science career. The scope of application of robotics education is beyond imagination. With the advancement of technology, concepts like cloud computing, artificial intelligence, gamification, face-recognition, voice-recognition, and numerous innovative applications have a wide scope of application in learning sciences.

Main Theme 2: Robotics Training

Schools these days are providing robotics education in various ways, such as after-school programmes, summer camps, weekend programmes, and value-added programmes, as they believe that it benefits students' academic performance (Rusk et al., 2008). Scandinavian countries such as Europe, UK and US have national directives to provide robotics education and enhance the quality of education. Students using robotics have excelled in STEM subjects and have won global robotics competitions for their innovative ideas. Science teachers are expected to guide students to participate in robotics competitions, but they lack knowledge in guiding them. Therefore, to strengthen the quality of science education, including robotics training for science teacher trainees in their pedagogical subject or in educational technology is the need of the hour.

a) Subtheme: Unexplored

Teacher educators and science teachers have mentioned that teacher education programmes must explore the opportunities to provide training in educational robotics. Even students have suggested that teachers could use robotics in science classes. Two of the female teacher educators (P4 and P5) have expressed their own doubts about robotics education, which has the potential to trigger innovation and discoveries. National policies of teacher education in a few countries of the world have taken steps to involve robotics training in their teacher education programs and recently India in its new NEP (2020) mentioned it.

> *P7 - […] it is helpful if our professors teach us robotics…*
> *P4 – […] it sounds good but we do not have any professional training on it …*
> *P5 – […] I doubt whether teacher educators would like it…*

Main Theme 3: Benefits of Robotics Education

Robotics education inspires children to learn the subject and attracts them towards STEM subjects. Students get to learn coding skills along with it. They become more proactive, scientific, and acquire problem-solving skills. It is an active teaching-learning pedagogy, which helps in recognising students' creative talent and boosts their confidence in learning sciences.

a) Subtheme: Quality Science Education

Both teacher educators and teachers said that robotics is the best method of teaching STEM subjects. As certain science concepts are abstract, robotics helps to understand them and develops original thinking habits among students. It develops interest in STEM subjects and provides ideas for innovation. It triggers critical and creative thinking and collaborative learning opportunities (Blikstein, 2013). It also helps people to participate in competitions such as science fares and exhibitions at the national and international level.

P6 – […] it is helpful in participating at science competitions…
P12 – […] it provides first-hand experience in learning…Science subjects…

a) Subtheme: Innovation

Teachers, teacher educators, and teacher trainees believed that robotics develops a scientific attitude, scientific temper, and makes students feel like young scientists. It provides a platform for youngsters to become leaders in educational technology. There are many young student inventors who have become youthful programmers, application developers and drone makers. Robotics education is often the medium to communicate their scientific ideas. It is the reason why schools in the 21st century have subscribed to educational robotics as an extracurricular activity, and believed it would be supplementary to their academics.

Main Theme 4: Robotics Lab

The robotics lab helps in STEM education, which is part of a progressivist curriculum, leading to innovation in science and technology. Educational institutes must invest in establishing robotics lab and provide coaching at all levels of education. Training science teachers without educational robotics is perhaps an incomplete teacher-training programme. Teacher education has to setup robotics labs with fundamental gadgets, computers, and necessary online platforms. Teachers have to acquire the knowledge of conducting robotics practicum.

a) Subtheme: Investment

Teacher educators, teacher trainees and teachers have voiced the need for investment in basic robotics equipment, which has multipurpose applications. Teacher education institutes can upgrade their technology lab with robotics instruments. Schools may also open a robotics lab to encourage science learning. Many of the European schools have invested in FAB-LABs, Gamification LAB, and Robotics Lab (Cornetta et al., 2020).

b) Subtheme: Practicum Training

Teachers mentioned that hands-on training by teacher educators to teacher trainees majoring in sciences would help them use educational robotics at schools. Having trained in robotics education will enhance their job opportunities, while teaching robotics through projects and opportunities for professional development are plenty (Sullivan, 2008). Successful projects or winning in robotics events will give job satisfaction and there will be more interest and ideas to innovate. Teacher educators also mentioned that it is time to provide robotics training in teacher preparation programmes, which must include theory and practicum.

P1- robotics lab is interesting…we can also have it in the technology lab…
P8 - Robotics lab experience will make us confident teachers…and it will be useful in terms of job prospectus…

6.2. Results of Quantitative Analysis

This section covers the results of Chi-square test of association to understand whether high school students' interest, teacher educators' readiness, and parents' interest in robotics education is gender dependent or not. Tables 5 and 6 present the results of cross tabulation and Chi-square test measuring the null hypothesis. There is no association between high school students' gender and their interest in robotics education.

Table 5: High school students * Interest in robotics education cross tabulation

			Interest in Robotics education		Total
			Interested	Not interested	
High school students	Males	Count	36	14	50
		Expected Count	28.0	22.0	50.0
	Females	Count	20.0	30.0	50.0
		Expected Count	28.0	22.0	50.0

Table 6: Chi-square tests for high school students * Interest in robotics education

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.390[a]	1	.001		
Continuity Correction [b]	9.131	1	.003		
Likelihood Ratio	10.589	1	.001		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	10.286	1	.001		
N of Valid Cases	100				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 22.00.					
b. Computed only for a 2x2 table					

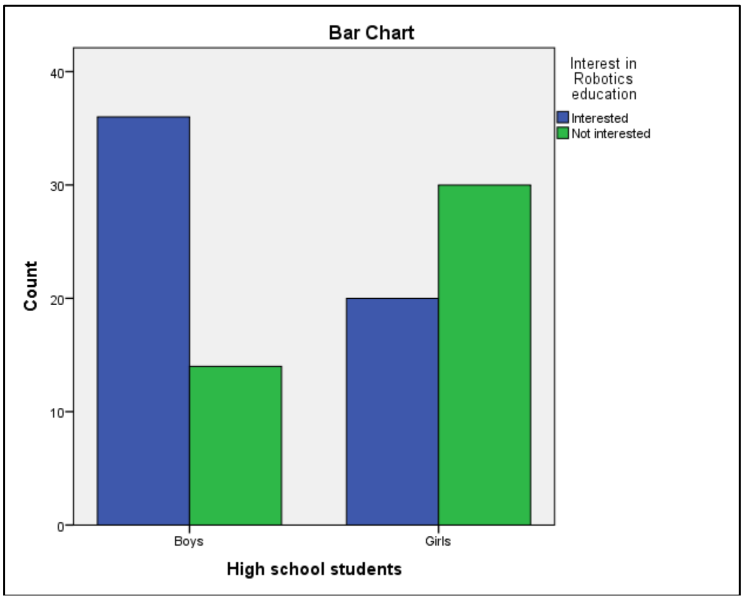

Figure 2: High school students' interest in robotics education

From the Tables 5 and 6, it is clear that all the expected cell frequencies are less than 28, therefore we infer from Fisher's exact test. There is a statistically significant association between high school students' gender and their interest in robotics education, $\chi2$ (1) = 10.390, Fisher's exact tests p = .002. Cramer's V value = 0.332 and its p = 0.01 indicating the size of the effect is medium. It is also evident from Figure 2.

Table 7 and 8 below present the results of cross tabulation and Chi-square test measuring the null hypothesis; there is no association between teacher educators' gender and their readiness to include robotics education in teacher education programme.

Table 7: Teacher educator * Inclusion of robotics Education Cross Tabulation

			Inclusion of Robotics Education		Total
			Yes	No	
Teacher Educator	Males	Count	18	7	25
		Expected Count	12.0	13.0	25.0
	Females	Count	6	19	25
		Expected Count	12.0	13.0	25.0

Table 8: Chi-Square Tests for Teacher Educator * Inclusion of Robotics Education

	Value	df.	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.538[a]	1	.001		
Continuity Correction [b]	9.696	1	.002		
Likelihood Ratio	12.033	1	.001		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	11.308	1	.001		
N of Valid Cases	50				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.00.					
b. Computed only for a 2x2 table					

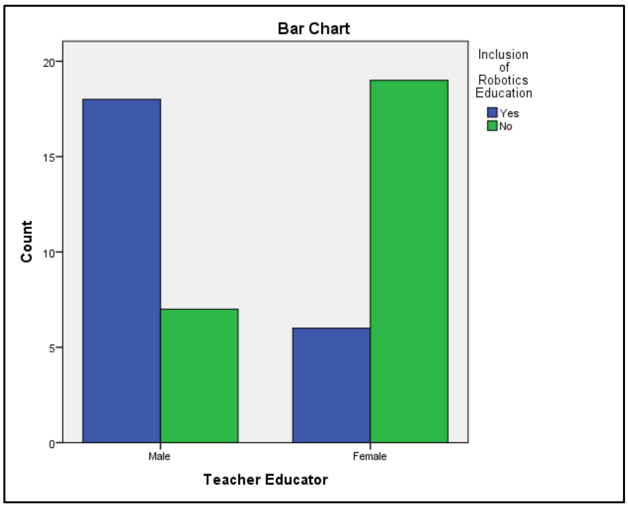

Figure 3: Teacher educators' readiness to include robotics education

From the Tables 7 and 8, it is found that the expected cell frequencies differ from observed cell frequencies and are greater than five, and therefore we infer from Pearson Chi-square value. There is a statistically significant association between teacher educators' gender and their readiness to include robotics education in teacher education programme respectively, $\chi 2$ (1) = 11.538, (Asymptotic Significance) p = .001. Cramer's V value = 0.480 and its p = 0.001 indicating the size of the effect is large (Kim, 2017). It is also evident from Figure 3 above.

Tables 9 and 10 below display the results of cross tabulation and Chi-square test measuring the association between parents' gender and their interest to invest in robotics education for their high school children.

Table 9: Parents gender * Interest to invest in robotics coaching cross tabulation

			Interest to invest in robotics coaching		Total
			Yes	No	
Parents' Gender	Males	Count	76	24	100
		Expected Count	58.0	42.0	100.0
	Females	Count	40	60	100
		Expected Count	58.0	42.0	100.0

Table 10: Chi-Square Tests Parents' gender * Interest to invest in robotics coaching

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	26.601[a]	1	.000		
Continuity Correction [b]	25.144	1	.000		
Likelihood Ratio	27.298	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	26.468	1	.000		
N of Valid Cases	200				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 42.00.					
b. Computed only for a 2x2 table					

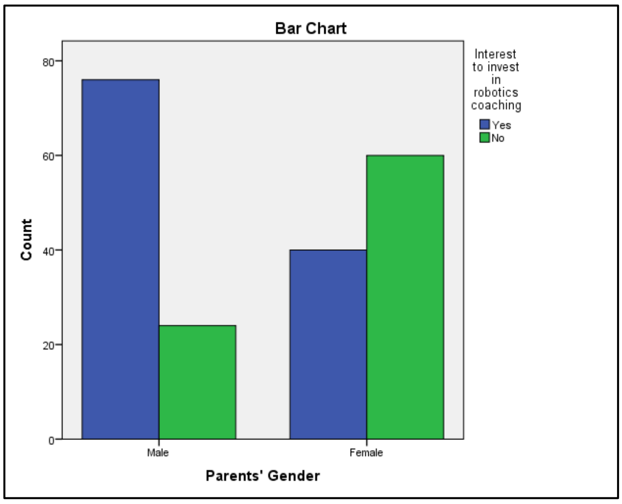

Figure 4: Parents' gender and interest to invest in robotics education

From the Tables 9 and 10, it is clear that the expected cell frequencies differ from observed cell frequencies and are greater than five, which means that we infer from Pearson Chi-square value. There is a statistically significant association between parents' gender and their interest to invest in robotics education for their high school children, $\chi 2$ (1) = 26.601, (Asymptotic Significance) p = .000. Cramer's V value = 0.365 and its p = 0.000 revealing that the size of the effect is almost large (Kim, 2017). It is also evident from Figure 4 above.

Inter-rater Reliability

The present study employed the inter-rater reliability method to finalise the syllabus framed. Researchers initially constructed the draft syllabus and checked it from its face validity and content validity among themselves. It was then processed for inter-rater reliability analysis. Accordingly, the researchers created a panel of experts who are science teacher educators, with equal representation to gender. Teacher educators willing to participate in the study were only included in the panel. Researchers briefed all the teacher educators about their purpose. After obtaining their informed consent, the draft syllabus has been shared with 20 science teacher educators, out of which 10 were male and 10 were female. Teacher educators responded to the draft syllabus on a 10 points rating scale, ranging from least to appropriate and gave their suggestions wherever necessary.

The investigators subjected the inter-rater ratings to intra-class reliability analysis. They found the Alpha value of 0.984 indicating the high reliability of the constructed syllabus. Table 11 below shows the results of intra-class correlation coefficient analysis.

Table 11: Intra-class correlation coefficient

	Intra-class Correlation [b]	**95% Confidence Interval**		**F Test with True Value 0**			
		Lower Bound	**Upper Bound**	**Value**	**df1**	**df2**	**Sig**
Single Measures	.753[a]	.600	.895	62.123	12	228	.000
Average Measures	.984[c]	.968	.994	62.123	12	228	.000
Two-way mixed effects model where people's effects are random and measures' effects are fixed.							
a. The estimator is the same, whether the interaction effect is present or not.							
b. Type C intra-class correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.							
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.							

From the above table, all the 20 raters had almost 98% agreement with the constructed syllabus. However, if you take a single measure, an agreement of 75.3% is obtained for each item of the constructed syllabus (Morgan et al., 2004).

This mixed method research revealed the perspectives of teacher educators, teacher trainees, and secondary school science teachers on the need and scope of robotics education. The inductive analysis of the interview data came up with four main themes and seven subthemes highlighting the need and scope of robotics education. The themes have revealed the need for robotics education, as it develops better understanding of science concepts, applications, and captures the interest and attention of learners.

All the participants readily agreed that robotics education is the future of science and students have to be educated on its use. Participants strongly believed that there is a need for investment in robotics labs and for practical training for students. It enhances students' critical thinking ability in sciences and paves the way to innovation. It provides them a sense of the global competitive spirit and develops a scientific temper in them. However, a few of the female teacher educators expressed their own doubts about its implementation.

The study also observed that Indian traditional and cultural aspects and gender-science stereotypes affect the prevalence and implementation of robotics education. The study revealed that boys have shown more interest in robotics education than girls. Parents' interest in investment in robotics education for their children has the influence of gender. Similarly, teacher educators' readiness to include robotics education as part of their programme is also influenced by gender. The study found that in spite of several research studies, discussing the benefits of educational robotics, its acceptance and implementation as part of the school's curriculum is suffering from gender-science stereotype. Teacher education colleges have not thought of initiating robotics training in their programmes nor attempted to create any syllabus. The study clearly pointed out the need for systematic planning, awareness, and a positive attitude towards providing robotics education and training. The study urged that the female audience should break this stereotyped mindset and participate in science education, irrespective of its nature, and the male audience need to encourage and accommodate women in science education. The present study brought out a suggestive syllabus on robotics education and suggestive practicum activities to be included in the training of teacher trainees majoring in science subjects. The study hopes that teacher education authorities would receive it positively and take steps to implement the suggested syllabus and the practicum. The new NEP (2020) has also emphasised the need for robotics education in schools and colleges (Govinda, 2020; Nandini, 2020). The study recommends that future researchers should work towards setting up robotics labs and include robotics education as part of school and college curricula.

7. Conclusion and Implication

Educational robotics is a way forward for STEM and STEAM education and attracts students to pursue higher education in the sciences, which contributes to the economic development. Unfortunately, higher education in sciences is suffering from gender-science stereotypes across the globe. The present study clearly reveals the need for robotics education from students', teachers', parents', and teacher educators' perspectives through a qualitative method. The study clearly confirms the presence of gender-science stereotype in affecting the prevalence and emergence of robotics education. Students' interest towards robotics learning, parents' interest in investing in robotics coaching for their wards, and teacher educators' readiness to offer robotics training to teacher trainees majoring in sciences are gender dependent. The study suggests a valid syllabus and training practicum on educational robotics to initiate robotics training at teacher education colleges. The study limited the opinion on robotics education from teacher educators, teacher trainees, teachers, students, and parents. It emphasises the need for investment in educational robotics, eliminating gender-science stereotypes and developing a positive attitude towards robotics education. The present study urges stakeholders to implement robotics in schools, colleges, and in teacher education. Only if robotics is added to the teacher preparation curriculum would teachers have the skills and knowledge to prepare students for the 21st century.

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Appendix1

Inter rater Reliability Pro Forma with Robotics Teacher Training Syllabus

Syllabus content		Rater rating																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Unit title: Introduction to Educational Robotics	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
2	Meaning and nature of Educational robotics	8	8	7	8	7	8	7	8	8	7	8	8	7	8	8	7	8	8	7	8
3	Theories behind educational robotics	9	8	5	8	7	8	6	6	6	10	8	7	7	7	7	7	7	7	7	7
4	constructivism and constructionism	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
5	Potentials of robotics in education	9	8	8	8	7	8	8	7	6	10	9	7	7	6	7	7	6	7	6	7
6	Applications of robots in daily life	9	9	8	9	8	9	9	8	9	9	8	9	9	8	8	9	9	8	9	9
7	Demonstration of a robotics package	8	7	6	8	7	6	7	7	8	6	8	8	8	8	8	8	8	8	8	8
8	Fundamental programming for robotics	6	6	5	5	6	5	6	6	7	6	8	6	6	5	6	6	7	6	6	6
9	Making decision and Loop control behaviors' in computer programs	9	8	7	9	8	7	9	9	8	8	7	9	7	9	8	7	9	9	8	9
10	Time required teaching the unit: 10 hours	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11	Practicum - Creating a Robot	9	8	9	9	8	8	9	8	9	8	9	9	8	8	8	9	9	8	9	9
12	Time required for Practicum 10 hours	10	10	10	9	10	10	10	10	9	10	10	10	8	10	10	9	10	10	9	10
13	**Practicum details** Teacher educator to demonstrate Robot construction plan, which involve creating a scenario, sketching a plan, executing the plan using robotics kit. After demonstration, the teacher educator may invite teacher trainees majoring in science to come up with a scenario in which robotics intervention needed, discuss the plan with teacher educator, draw a schematic diagram of the plan, chose the materials required to build the robots from the available robotics kit, construct the robots, and execute (Daniela et al., 2014). The teacher educator and trainee then hold a debriefing session to discuss the pros and cons of the constructed robot and its utility. Teacher trainees then use the robotics kit on multi-principle platforms such as Lego mind storm NXT package, Make block Ultimate Robot Kit-Blue, Bioloid STEM standard kit, Arduino Robot Kit, Sun Founder Crawling Quadruped Robot DIY Kit for Arduino Part with Nano Board Remote Control etc.																				
14	**Suggestions:**																				