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Innovative Teaching Strategies for Training of Future Mathematics in Higher Education Institutions in India

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Abstract: The purpose of the article is to analyze teaching strategies used during the future mathematicians training in India and to select the most effective ones. The objectives include: to carry out a close-open survey in order to distinguish the teaching strategies used in mathematics education; to establish traditional and innovative teaching strategies and describe the difficulties; to assess plausibility of hypothesis and to outline the most efficient teaching strategies. Within the framework of research 28 works published from 2018 to 2022 and devoted to the problems of mathematics education in Indian higher educational institutions were analyzed. A number of legislative documents and teachers' guidelines were studied in order to outline the government policy on education modernization and the principles of organization of educational process in India. The deductive approach to apply theoretical methods like literature review and analysis of research results was used. Empirical research methods included a close survey, mathematical analysis and statutory interpretation of answers. The numerical data contributed to the assessment of plausibility of hypothesis and proved that innovative teaching strategies make the educational process more effective. The close survey was conducted during 2022- 2023 academic year. It includes three stages: preparatory, experiment and final. The close survey involved 216 mathematics teachers from different higher educational institutions throughout India. The

results show that traditional teaching strategies are still widely used in Indian educational institutions. Nevertheless innovations are essential to present qualitative changes in the system of education. The following innovative teaching strategies were used: bilingual education, inter-subject links, mobile learning, microteaching, gamification, ICT, flipped classroom, personalized learning. These strategies improve learning outcomes among students, increase the creativity, communication skills, decision-making, and professional flexibility, enhance motivation, increase interest to professional activity, provide better understanding of materials, form professional competency, and contribute to decision-making skills formation.

Keywords: mathematics education, future mathematicians, innovative teaching strategy, traditional teaching-learning model.

Introduction

The main strategic task for modern society and education development is closely connected with the process of development of human intellectual and cultural potential. Obviously, there is a need to create all the favourable conditions that could facilitate the fulfillment of this task and provide highly qualified pedagogical support. Formal education interprets mathematics as one of the most important fields studied by students as they are expected to apply mathematics thought patterns and rules of logics, mathematics skills in everyday life. Moreover, mathematics contributes to the effective formation of learning skills, critical thinking, information literacy, assessment skills, metacognition ability, problem solving, and decision making.

Mathematics originates from the Vedic period (Chand & Das, 2022a; Chorlay et al., 2022) and is still very popular in India. According to All India Survey on Higher Education 2019-20 (Government of India, 2020a), in 2019 143116 students enrolled in mathematics which is the highest among all the science streams. In 2020 the total enrolment in mathematics was 104269 students nevertheless the specialization took the second place among the youth after chemistry. Also, mathematics in one of the popular science streams for Ph.D. enrolment being number three after chemistry and physics (Government of India, 2021).

BSc Maths can apply for a job as a data analyst, teacher, investment analyst, and accountant or machine learning engineer. Students can also apply for further programs like MSc Maths, MSc Financial Mathematics and Computation, MBA in Finance, Chartered Financial Analyst, and Financial Risk Management. Mathematicians have the possibility to work in banking, accountancy, financial management, public administration, computing and IT, space science, military command, engineering, stock exchange, universities or consultancy centers, government sector.

This scope shows that mathematics education and the training of future mathematicians is a very urgent problem in India and requires a deep analysis of traditional and innovative approaches in order to choose the most effective ones.

Research Problem

According to Satapathy and Malhotra (2020), teaching strategies used in order to train future specialist must be supportive and oriented towards the achievement of pedagogical intention. Other scientists insist that sustainable innovations implemented towards teaching-learning model may significantly improve the learning outcomes and prepare students to act efficiently in future (Dimple,

2018). Obviously, education must accept changes occurring in the society and maintain improvement in productivity, efficiency, and quality forming professional competency among students.

Therefore, the problem of the most efficient methods selection in mathematics education is especially acute as it may contribute to improvement of future mathematicians training and, as a result, provide economics with highly-qualified specialists who have sufficient mathematics skills and are ready to work in the surrounding changing.

Research Focus

The world is undergoing rapid changes and employing a number of intense scientific and technological advances including the rise of big data, machine learning, and artificial intelligence. As a result, the Indian society demand skilled workforce with high level of mathematics competency (Government of India, 2020b). The process of future mathematicians training at the educational establishments concerns teaching theoretical knowledge to students and formation of practical skills that will help to solve mathematical tasks in the future professional activities.

The methodology deals with the goal-oriented organization of educational process and appropriate selection of teaching strategies in accordance with the learning objectives, students' needs, content of learning, and components of future professional activity (Munna & Kalam, 2021; Nishitha, 2019). Otherwise, methodology is teacher's mastery in student's learning activity to organising and encouragement to knowledge acquisition. In the context of mathematics education, methodology is a multi-aspect phenomenon, independent, dynamic and complex system of teaching strategies influencing the level of mathematics knowledge and skills as well as sufficient level of professional-mathematics skills.

Findings show that traditional teaching strategies are still widely used in Indian educational institutions. The main reason is that traditional education is to transfer the values, moral and social skills adopted in the society to the youth. Traditional teaching strategies mainly refer to oral forms of instruction like lectures and demonstration (Sethi, 2021). The analysis of scientific sources (Abd Algani & Eshan, 2023; Nishitha, 2019; Puranik, 2022; Sethi, 2021) and teachers' guidelines or other educational materials published by some Indian educational institutions (Castelino & Hegde, 2020) show that traditional strategies are the following: exercise and practice, home assignments, analysis and correction of home assignments, oral lectures, written tasks, group work, self-study, supervised study, review, problem solving, chalk and talk method, real time example.

However currently traditional teaching strategies show less efficiency and there are requirements to modernize the educational process (Naga Subramani & Iyappan, 2018; Puranik, 2022). Education thus, must move towards formation of creative and innovative specialists being ready to act in changing field. Obviously, the quality of training significantly depends on methodology as it influences the not only students' learning outcomes but increases their motivation to gain future specialization, adaptability qualities, and self-education skills. Methodology must make education more experiential, integrated, discovery-oriented, learner-centered, discussion-based, gamified, flexible, and interesting (Government of India, 2020b).

This need stems from a number of difficulties or educational deviations caused by the wide use of traditional strategies. Table 1 shows the analysis of educational deviations on the basis of Indian scientific literature review.

Table 1

Difficulties Caused by the Wide Usage of Traditional Strategies

Difficulties in traditional teaching	Authors
Applying a single method	Borikar and Seikdar (2019), Sethi (2021).
Preparing a poor lesson plan	Sethi (2021).
Lack of advanced training for teachers	Borikar and Seikdar (2019), Sethi (2021).
Lack of mathematics kits at the educational institution or use of outdated educational materials	Puranik (2022), Sethi (2021).
Different students' abilities and difficulties to assess all the learners	Das (2019d), Naga Subramani and Iyappan (2018), Sethi (2021), Verma (2019).
Shortage of computer hardware	Das (2021), Sethi (2021).
High student/teacher ratio	Chand and Das (2022a), Das (2019a), Sethi (2021).
Lack of information and communication technologies (ICT) skills among students and teachers	Das (2019b), Das (2019d), Sethi (2021), Umamet al. (2019)
Inability to integrate ICT to pedagogy	Das (2019c), Das (2021), Sethi (2021).
Lack of interest or motivation among students	Das (2019d), Sethi (2021).
Difficulties in adopting a new strategy in the classroom	Das (2021), Sethi (2021),.
Lack of interactive methods	Borikar and Seikdar (2019), Das (2019d), Das (2021), Sethi (2021), Verma (2019).
Necessity to incorporate game-based approach and play-way learning	Aggarwal (2022), Das (2021), Verma (2019).
Individual students' characteristics like self-assessment, self-education	Das (2019d).
Poor planning or inadequate curriculum	Das (2019d).
Inadequate content materials	Borikar and Seikdar (2019), Das (2019d).
Irrelevant features of learning environment and requirement to maintain more balanced classroom environment	Borikar and Seikdar (2019), Das (2019d), Das (2021).
Poor inter-subject links	Das (2019a), Das (2019d), Das et al. (2019).
Requirement to use ICT and digital technologies more extensively	Albina (2018), Das (2019a), Das (2019c), Das (2021), Mondal and Roy (2021), Umam et al. (2019).
Change of learning styles	Aggarwal (2022), Das (2021).
Mathematics phobia	Das (2021), Das and Gupta (2020).
Necessity to create encouraging materials for advanced learning	Das (2019a), Das (2019b), Albina(2018).
Use of realistic mathematics exercises	Das (2021), Das (2019a).
Low support of government	Das (2021).
Teaching through Internet	Albina (2018), Das (2021).
Lack of adequate skills of teachers to create effective and creative learning environment	Das (2019a), Das (2021), Verma (2019).
Use of different languages by learners like mother tongue, regional language, official language of the union, associate official language	Das (2019a), Dimple (2018), Sethi (2021).

Source: based on literature review.

A number of faced difficulties while teaching mathematics at the higher educational institutions in India affirm the necessity to focus upon employment of innovative teaching strategies as well to make

the educational process more efficient. This fact is also confirmed by Indian educators and scholars (Aggarwal, 2022; Das, 2019c; Nishitha, 2019; Puranik, 2022) who consider innovations are essential to present qualitative changes in the system of education.

The main purpose of innovative teaching strategies is to make teaching mathematics more interactive as well as effective (Sethi, 2021). In addition, innovations improve methodological approaches, teaching methods or tools, facilitates the educational process (Bhinder, 2018). According to Puranik (2022) traditional teaching methodology is outdated and innovative methods are to be identified in order to enhance pedagogical competency of teachers as well as learning outcomes of students. Obviously, there is a strong need to change pedagogy from fact-based and oral lecturing to interactive teaching.

Acharya and Johny (2020) insist that traditional teaching methods oriented towards learning through memorization and recitation techniques must be changed into innovative strategies that induce critical thinking and problem-solving methods. At the same time, education, particularly mathematics teaching, is affected by technology-based innovations that create flexible and appropriate educational environment. As a result, some scholars (Aggarwal, 2022; Albina, 2018; Das, 2019c) claim that ICT is a necessary component of innovative teaching strategies and while teaching mathematics educators must focus on using multimedia, digital tools, e-learning applications, and mobile devices to make learning more interesting and comfortable. These changes were accelerated by government initiatives towards creation of distance education support during the COVID-19 pandemic (Das, 2021; Mondal & Roy, 2021).

Therefore, the application of efficient teaching strategies, traditional or innovative, in mathematics education is a necessary condition in order to enhance the professional competency of future mathematicians' level. Moreover, efficient educational environment prepares students to act under changing conditions and apply mathematics skills properly.

Research Aim and Research Questions

The purpose of the article is to analyze teaching strategies used for training of future mathematicians in India and to reveal the most effective methods able to improve mathematics education in the higher educational institutions.

The article objectives are the following:

- to carry out a close survey among teachers in Indian higher educational institutions and to distinguish the teaching strategies used in mathematics education;

- to establish traditional and innovative teaching strategies on the basis of teachers survey and describe the difficulties educators face within the educational process;

- to assess the hypothesis plausibility and to outline the most efficient teaching strategies able to improve mathematics education in Indian higher educational institutions.

Research Methodology

General Background

In this research the deductive approach that suggests applying theoretical methods like literature review and analysis of research results related to mathematics education in Indian higher educational institutions was used. These methods helped to establish already used in the educational process

teaching strategies and to develop new hypothesis to be verified. Empirical research methods including close survey in order to collect quantitative data on the problem. To analyze the results, mathematical analysis and statutory interpretation of teacher's answers were used. The numerical data contributed to the assessment of hypothesis plausibility and proved that innovative teaching strategies make the educational process more effective.

Sample / Participants / Group

The close survey was conducted during 2022-2023 academic year and included three stages: preparatory stage (May-August, 2022) when the literature review was carried out and the hypothesis was developed on the basis of findings; experiment stage (September-December, 2022) during this period the close survey was conducted; the final stage (January-February, 2023) was focused on the elaboration of recommendations for teaching stuff of Indian higher educational institutions. The empirical research involved 216 mathematics teachers from different higher educational institutions throughout India who filled in the questionnaire through Google forms. We informed the respondents about the survey objectives and all the teachers participated voluntarily.

Instrument and Procedures

The teachers were questioned through Google forms online to obtain necessary quantitative and qualitative data for the hypothesis verification. The questions referred to the teaching strategies used in the educational process to teach future mathematics in Indian higher educational institutions. The teaching staff was asked to assess the difficulties they face in the educational process. Some questions referred to the usage of innovative teaching strategies as we hypothesized that they contribute to modernization of mathematics education and help to prepare future mathematicians to professional activity more efficiently. Figures 1.1 and 1.2 show the questionnaires used in the close survey.

Figure 1.1

Form Used to Reveal Traditional and Innovative Teaching Strategies in the Process of Training of Future Mathematicians

You are kindly requested to fill in the following form in order to find out traditional and innovative teaching strategies used in the process of training of future mathematicians. Your answers will be used for the improvement of mathematics education in Indian higher educational institutions. Please, answer objectively and impartially. Thank you for your cooperation!			
1. What is your teaching experience?			
a) less than 5 years	b) 5-10 years	c) 10-15 years	d) more than 15 years
2. What is your pedagogical load?			
a) full time		b) part-time	
3. Do you use teachers' guidelines?			
a) yes, strictly follow	b) yes, mostly follow	c) use some main recommendations	d) no, use own experience
4. Do you use traditional teaching strategies while teaching?			
a) yes, always	b) yes, very often	c) rarely	d) do not use
. Read the following traditional strategies and answer whether you use them for teaching future mathematicians. Answer using grades from 1 to 4, where 1 means avoid using and consider innovative strategies are more effective; 2 = use rarely; 3 = use often; 4 = usealways. **6. Drill and practice**			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
7. Oral lecturing			

a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
8. Seminars			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
9. Panel discussions			
a) 1= avoid using	**b) 2= use rarely**	**c) 3= use often**	**d) 4= use always**
10. Home assignments			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
11. Analysis and correction of home assignments			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
12. Written tasks			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
13. Independent work			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
14. Group work			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
15. Supervised study			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
16. Problem solving			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
17. Work with textbook			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
18. Chalk and talk method			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
19. Real time example			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
20. Laboratory work			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
21. Do you face difficulties while using traditional teaching strategies?			
a) yes, always	a) yes, always	a) yes, always	a) yes, always
22. Do you apply innovative teaching strategies?			
a) yes, always	a) yes, always	a) yes, always	a) yes, always
Read the following innovative strategies and answer whether you use them for teaching future mathematicians. Answer using grades from 1 to 4, where 1 means avoid using and consider traditional strategies are more effective; 2 = use rarely; 3 = use often; 4 = use always. **23. Bilingual education**			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
24. Inter-subject links or integrated approach			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
25. Mobile learning			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
26. Microteaching			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
27. Gamification			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
28. Use of ICT			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
29. Flipped classroom			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
30. Personalized learning			
a) 1= avoid using	b) 2= use rarely	c) 3= use often	d) 4= use always
31. How do innovative teaching strategies affect the educational process?			

a) they bring positive changes	a) they bring positive changes	a) they bring positive changes	a) they bring positive changes
32. How do learning outcomes change when you apply innovative teaching strategies?			
a) improve significantly	a) improve significantly	a) improve significantly	a) improve significantly

Source: based on literature review.

Figure 1.2

Form Used to Reveal Traditional and Innovative Teaching Strategies in the Process of Training of Future Mathematicians

You are kindly requested to fill in the following form in order to analyze the difficulties you face in the educational process. Your answers will be used in the improvement of mathematics education in Indian higher educational institutions. Please, answer objectively and impartially. Thank you for your cooperation!			
Look through the following list of difficulties occurring in the educational process and grade them in four points where 1 means do not face at all; 2 = rarely; 3 = often; 4 = always.			
1. Applying a single method			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
2. Preparing a poor lesson plan			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
3. Lack of advanced training for teachers			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
4. Lack of mathematics kits at the educational institution or use of outdated educational materials			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
5. Different students' abilities and difficulties to assess all the learners			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
6. Shortage of computer hardware			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
7. High student/teacher ratio			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
8. The lack of information and communication technologies (ICT) skills among students and teachers			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
9. Inability to integrate ICT to pedagogy			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
10. Lack of interest or motivation among students			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
11. Difficulties in adopting a new strategy in the classroom			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
12. Lack of interactive methods			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
13. The necessity to incorporate game-based approach and play-way learning			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
14. Individual students' characteristics like self-assessment, self-education			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
15. Poor planning or inadequate curriculum			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
16. Inadequate content materials			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
17. Irrelevant features of learning environment and requirement to maintain more balanced classroom environment			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
18. Poor inter-subject links			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
19. Requirement to use ICT and digital technologies more extensively			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
20. Change of learning styles			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
21. Mathematics phobia			

a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
22. A necessity to create encouraging materials for advanced learning			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
23. The use of realistic mathematics exercises			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
24. Low support of government			
a) 1 = never	**b) 2 = rarely**	**c) 3 = often**	**d) 4 = always**
25. Teaching through Internet			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
26. The lack of adequate skills of teachers to create effective and creative learning environment			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
27. The use of different languages by learners like mother tongue, regional language, official language of the union, associate official language			
a) 1 = never	b) 2 = rarely	c) 3 = often	d) 4 = always
Read the following statements and say whether you agree or not. Describe your agreement in four points where 1 = completely agree; 2 = mainly agree; 3 = agree partially; 4 = do not agree. **28. Implementation of innovations is very important in mathematics education.**			
a) 1 = completely agree	b) 2 = mainly agree	c) 3 = partially agree	d) 4 = do not agree
29. Innovations are objective changes to modernize training of future mathematicians.			
a) 1 = completely agree	b) 2 = mainly agree	c) 3 = partially agree	d) 4 = do not agree
30. Do you undergo advanced training regularly?			
a) every year	b) every three years	c) every five years	d) do not remember exactly

Source: based on literature review.

Data Analysis

One analyzed the numeric data obtained during the survey that was focused to reveal the main teaching strategies used in the process of training of future mathematicians in Indian higher educational institutions and to assess the hypothesis plausibility that innovative teaching strategies are to be implemented more extensively. Also, the answers allowed us to describe the difficulties while using traditional teaching strategies. We presented our findings in the following sections below.

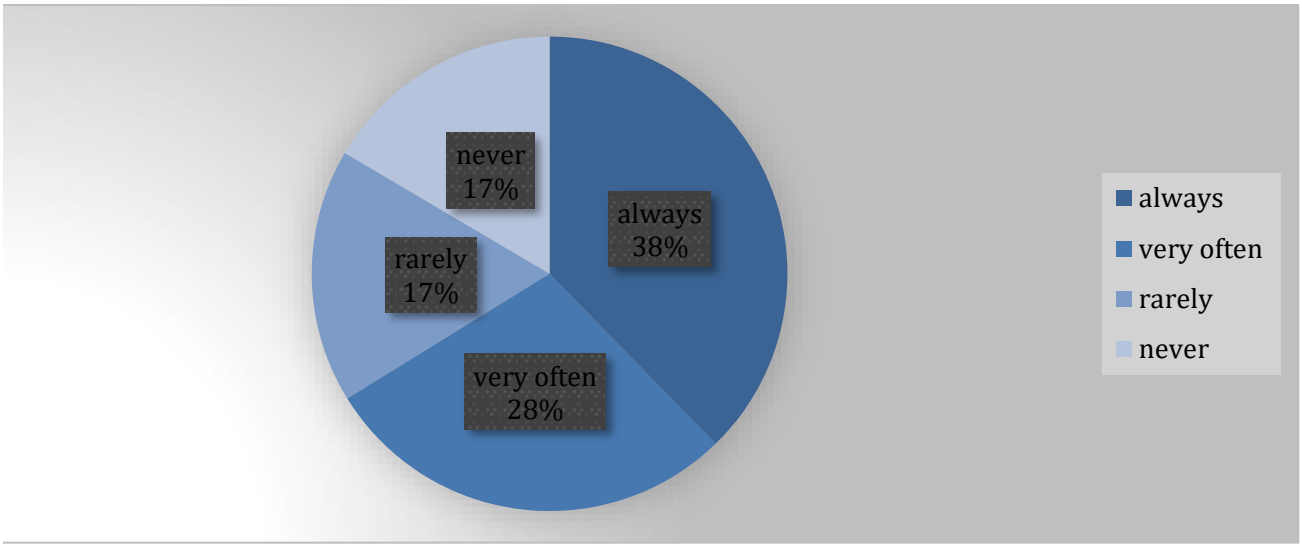
Research Results

The results of the close survey show that still a big number of teachers in Indian higher educational institutions apply traditional teaching strategies. Teachers explain their choice by the fact that teachers' guidelines recommend traditional strategies and many educators consider that such strategies help to preserve community values, improve moral and social skills and maintain national identity. Some teachers consider that innovative teaching strategies require additional workload.

Figure 2 shows that 38 % of teachers use traditional teaching strategies at each lesson and 28 % of teaching staff still choose traditional approaches to teaching mathematics. 17 % of teachers try to use traditional teaching strategies rarely and the same quantity avoid using traditional techniques in most cases as they consider innovative technologies are very effective in the process of training of future mathematicians. These findings show that teachers are very focused on preserving the existing traditions in the system of education and are not ready to immediately change their teaching strategies. At the same time the survey showed that young teachers are less comfortable at using traditional teaching strategies.

Figure 2

Quantity of Teachers Using Traditional Teaching Strategies in Indian Higher Educational Institutions



Source: based on survey results.

Analyzing the use of traditional teaching strategies in mathematics education in Indian higher educational institutions, it was evaluated that almost in each lessons 31,0 % of teachers use oral lecturing, 30,8 % - seminars, 50,1 % - home assignments, 40,8 % analysis and correction of home assignments, 35,7% - independent work, 34,0 % - work with textbook. At the same time, the findings show that some traditional teaching strategies are less applicable in mathematics education. They are the following: panel discussion, group work, real time examples, and laboratory work. Thus, 24,3 % of teachers never use panel discussion, 24,6 % of teachers avoid applying group work, 29,4 % of educators do not use real time examples at the lessons, and 21,0 % of teaching staff do not use laboratory work as their subject do not have the adopted algorithm for this.

Table 2

Analysis of Traditional Teaching Strategies Used in Mathematics Education in Indian Higher Educational Institutions

Traditional teaching strategies used in the process of training of future mathematicians	% of teachers			
	always	often	rarely	never
Exercise and practice	17,2 %	39,5 %	26,4 %	16,9 %
Oral lecturing	31,0 %	36,1 %	22,4 %	10,5 %
Seminars	30,8 %	33,1 %	18,5 %	17,6 %
Panel discussion	18,5 %	24,9 %	32,3 %	24,3 %
Home assignments	50,1 %	42,4 %	6,7 %	0,8 %
Analysis and correction of home assignments	40,8 %	34,9 %	20,3 %	4,0 %
Written tasks	32,6 %	34,4 %	18,1 %	14,9 %
Independent work	35,7 %	30,5 %	20,6 %	13,2 %
Group work	20,1 %	24,7 %	30,6 %	24,6 %
Supervised study	15,8 %	20,9 %	32,3 %	31,0 %
Problem solving	27,6 %	30,8 %	28,1 %	13,5 %
Work with textbook	34,0 %	31,1 %	19,4 %	15,5 %
Chalk and talk method	39,9 %	30,2 %	13,3 %	16,6 %
Real time example	18,7 %	21,2 %	30,7 %	29,4 %
Laboratory work	23,1 %	26,7 %	29,2 %	21,0 %

Source: based on survey results.

Despite the wide use of traditional teaching strategies respondents indicated in the questionnaire that they face difficulties that hinder the educational process and affect students' learning outcomes adversely. Table 3 presents the analysis of traditional teaching strategies used to train future mathematicians in Indian higher educational establishments.

The findings show that the most frequent difficulties are the following: high student/teacher ratio (30,7 %), difficulties in adopting a new strategy in the classroom (31,2 %), lack of interactive methods (39,4 %), necessity to incorporate game-based approach and play-way learning (32,9 %), requirement to use ICT and digital technologies more extensively (30,1 %), individual students' characteristics like self- assessment, self-education (29,7 %), and inability to integrate ICT to pedagogy (25,8 %), poor inter-subject links (29,5 %), and change of learning styles (23,5 %). At the same time, teachers specified some difficulties as less common. They include mathematics phobia that is typical for first-year students (0,2 %), low support of government (2,7 %), use of different languages by learners and necessity to teach in unified language or apply bilingual education (3,7 %).

Table 3

Analysis of Traditional Teaching Strategies Used in Mathematics Education in Indian Higher Educational Institutions

Difficulties facing while using traditional teaching strategies	% of teachers			
	always	often	rarely	never
Applying a single method	15,3 %	27,8 %	33,7 %	23,2 %
Preparing a poor lesson plan	10,6 %	20,5 %	40,8 %	28,1 %
Lack of advanced training for teachers	7,8 %	21,3 %	38,5 %	32,4 %
Lack of mathematics kits at the educational institution or use of outdated educational materials	12,9 %	29,6 %	24,1 %	33,4 %
Different students' abilities and difficulties to assess all the learners	27,8 %	30,6 %	20,6 %	21,0 %
Shortage of computer hardware	11,6 %	35,7 %	30,3 %	22,4 %
High student/teacher ratio	30,7 %	31,1 %	20,5 %	17,7 %
Lack of information and communication technologies (ICT) skills among students and teachers	28,9 %	25,6 %	30,2 %	15,3 %
Inability to integrate ICT to pedagogy	25,8 %	28,1 %	23,9 %	22,2 %
Lack of interest or motivation among students	20,6 %	22,3 %	31,5 %	25,6 %
Difficulties in adopting a new strategy in the classroom	31,2 %	32,7 %	20,9 %	15,2 %
Lack of interactive methods	39,4 %	31,8 %	17,0 %	11,8 %
Necessity to incorporate game-based approach and play-way learning	32,9 %	33,6 %	24,5 %	9,0 %
Individual students' characteristics like self-assessment, self-education	29,7 %	32,2 %	30,8 %	7,3 %
Poor planning or inadequate curriculum	19,7 %	38,9 %	28,7 %	12,7 %
Inadequate content materials	18,3 %	34,1 %	31,4 %	16,2 %
Irrelevant features of learning environment and requirement to maintain more balanced classroom environment	21,9 %	26,7 %	29,8 %	21,6 %
Poor inter-subject links	29,5 %	27,1 %	23,7 %	19,7 %
Requirement to use ICT and digital technologies more extensively	30,1 %	26,4 %	23,5 %	20,0 %
Change of learning styles	23,5 %	29,1 %	24,9 %	22,5 %
Mathematics phobia	0,2 %	3,6 %	12,5 %	83,7 %
Necessity to create encouraging materials for advanced learning	19,1 %	22,4 %	31,7 %	26,8 %
Use of realistic mathematics exercises	12,3 %	28,1 %	34,2 %	25,4 %
Low support of government	2,7 %	17,3 %	67,9 %	12,1 %
Teaching through Internet	15,5 %	23,4 %	39,3 %	21,8 %

Lack of adequate skills of teachers to create effective and creative learning environment	7,8 %	18,9 %	54,6 %	18,7 %
Use of different languages by learners like mother tongue, regional language, official language of the union, associate official language	3,7 %	29,1 %	42,0 %	25,2 %

Source: based on survey results.

The results demonstrate that purely traditional teaching-learning model leads to difficulties and, therefore, the educational process requires modernization or the use of innovations as the methods of knowledge acquisition change and profession of mathematician undergo deep transformations. The survey showed that teachers apply innovative teaching strategies but it does not happen extensively. One revealed that there are eight innovative teaching strategies used in the process of training future mathematicians. They are the following: bilingual education, inter-subject links or integrated approach, mobile learning, microteaching, gamification, ICT, flipped classroom, personalized learning. Table 4 gives the analysis of innovative teaching strategies used in mathematics education in Indian higher educational institutions.

The findings show that mobile learning, gamification, ICT, and personalized learning are the most common innovative teaching strategies. 28,7 % of teachers use mobile learning at each lesson, 29,8 % - gamification, 28,7 % - ICT, and 23,8 % - personalized learning. At the same time, a comparatively small amount of teachers apply bilingual education (3,9 %), inter-subject links or integrated approach (12,7 %), and flipped classroom (15,1 %). This is because the activities of teachers are regulated by institutional guidelines and so implementation of bilingual teaching, flipped classroom, or realization of inter-subject links are specified in curricula.

Table 4

Analysis of Innovative Teaching Strategies Used in Mathematics Education in Indian Higher Educational Institutions

Innovative teaching strategies used in the process of training of future mathematicians	% of teachers			
	always	often	rarely	never
Bilingual education	3,9 %	12,7 %	54,6 %	28,8 %
Inter-subject links or integrated approach	12,7 %	30,6 %	30,8 %	25,9 %
Mobile learning	28,7 %	40,5 %	19,4 %	11,4 %
Microteaching	17,6 %	29,7 %	40,2 %	12,5 %
Gamification	29,8 %	37,5 %	23,1 %	9,6 %
ICT	28,7 %	39,3 %	22,8 %	9,2 %
Flipped classroom	15,1 %	39,2 %	27,9 %	17,8 %
Personalized learning	23,8 %	32,5 %	37,0 %	6,7 %

Source: based on survey results.

During the survey one found that the use of innovative teaching strategies create a number of advantages and make the process of training of mathematicians in Indian higher educational institutions more efficient. The findings show that they improve not only the learning outcomes and mathematics skills among students but also increase the creativity, communication skills, decision-making, and professional flexibility positively. Thus, 53,5 % of teachers completely agree that innovative teaching strategies improve the creativity development, 60,2 % - enhancement of motivation to learning activities, 57,4 % - increase interest to professional activity, 54,9 % - understanding of materials, 65,3 % - formation of professional competency, 67,4 % student's learning outcomes, 59,1 % - formation of decision-making skills.

It was found that innovative teaching strategies have the least affect upon practicing of foreign language, development of personality and psychological readiness, and team building skills. Thus, only

19,8 % of teachers consider innovative teaching strategies help to enhance foreign language knowledge. 28,5 % of teachers consider that such strategies develop personality and psychological readiness. At the same time 18,6 % of educators think that students learn working in teams while training as future mathematicians. Table 5 shows the analysis of advantages using innovative teaching strategies in mathematics education in Indian higher educational institutions.

Table 5

Advantages of Using Innovative Teaching Strategies in Mathematics Education in Indian Higher Educational Institutions

Advantages of using innovative teaching strategies	% of teachers			
	Completely agree	Mainly agree	Partially agree	Do not agree
Development of creativity	53,5 %	24,7 %	12,2 %	9,6 %
Improvement of communication skills	40,1 %	27,3 %	17,8 %	14,8 %
Enhancement of motivation	60,2 %	29,1 %	7,3 %	3,4 %
Increasing of interest	57,4 %	30,3 %	11,0 %	1,3 %
Formation of leadership or facilitation skills	34,5 %	22,7 %	26,9 %	15,9 %
Better understanding of material	54,9 %	26,8 %	14,6 %	3,7 %
Preparation to use digital tools in future professional activity	48,4 %	32,1 %	17,1 %	2,4 %
Practicing foreign language	19,8 %	20,3 %	50,7 %	9,2 %
Formation of professional competency	65,3 %	23,1 %	9,5 %	2,1 %
Improvement of self-study skills	39,5 %	36,2 %	20,8 %	3,5 %
Modernization of educational materials	32,1 %	27,6 %	21,9 %	18,4 %
Improvement of students' learning outcomes	67,4 %	19,8 %	12,0 %	0,8 %
Teaching to work in teams	18,6 %	24,5 %	27,9 %	29,0 %
Improvement of critical thinking	43,9 %	25,1 %	18,4 %	12,6 %
Enhancement of professional flexibility	37,0 %	21,9 %	23,6 %	17,5 %
Development of personality and psychological readiness	28,5 %	23,5 %	26,0 %	22,0 %
Formation of decision-making skills	59,1 %	17,8 %	14,5 %	8,6 %
Training on the examples of real-life experience	29,4 %	39,4 %	18,9 %	12,3 %

Source: based on survey results.

Discussion

The systemic literature review and the close-open survey carried out among teachers of different higher educational institutions throughout India show that the use of innovative teaching technologies significantly improves the educational process and increase students' learning outcomes. They contribute to students' soft skills formation like critical thinking, creativity, communication or decision-making. At the same time, it is impossible to immediately and completely refuse traditional teaching strategies as the survey found traditional teaching help to transfer the values, moral and social skills and maintains national identity. In addition, mathematics education is regulated by normative documents like teachers' guidelines or methodical recommendations and their modernization requires time.

Innovative teaching strategies refer to new or modified forms, methods, techniques or principles of teaching and upbringing, oriented towards organization, management, and assessment of educational process improvement. The findings show that innovative teaching strategies gradually become applicable in mathematics education despite traditional teaching-learning models predominance in some institutions. It was found that bilingual education, inter-subject links or integrated approach, mobile learning, microteaching, gamification, ICT use, flipped classroom, and personalized learning are most common in Indian higher educational institutions. Table 6 characterizes these innovative teaching

strategies based on literature review (Aggarwal, 2022; Bhinder, 2018; Chand & Das, 2022b; Das, 2019c; Puranik, 2022; Sharma & Priyamvada, 2022; Umam et al., 2019) and survey results.

Table 6

Characteristics of Innovative Teaching Strategies Used in the Process of Training of Future Mathematicians in Indian Higher Educational Institutions

Innovative teaching strategies used in the process of training of future mathematicians	Description of innovative teaching strategies and their contribution to mathematics education
Bilingual education	process of teaching students using two languages; using of different levels of native and second language (usually unified one) depending on the requirements specified in teachers' guidelines; helps toimprove foreign language skills and integrate new specialist into community
Inter-subject links or integrated approach	Learning mathematics in combination with other subjects; building integrated understanding of professional activity and formation of readiness to solve difficult professional tasks in the sphere of mathematics; deals with introduction of mathematics notions and skills into other educational procedures and wide use of metacognition; contributes to the critical thinking development.
Mobile learning	Learning with portable devices like mobile phones, tablets, and laptops; helps to use a variety of educational videos and e-learning apps; helps to easy access, cove huge distances, test knowledge, and provides various content; used to encourage students to learning activities.
Microteaching	Refers to the explanation of new material in small portions by shaping the role of teacher and student; helps to reduce complexness of learning content; provides feedback and purposeful comments; contributes to formation of team building and leadership skills; helps to revise material and increases learning outcomes significantly.
Gamification	Includes play and fun activities in the classroom but students do not realize that they are learning as all the activities relate to mathematics; helps to apply content in different situations; engages students in the classroom; explains new material in simplified way; facilitate students and helps to self-evaluate; creates better understanding of new theory.
ICT use	Deals with networks that provide new opportunities for teaching-learning model through digital content; suggests using virtual environment, simulator, digital libraries, computer-assisted conferencing; enables students to solve difficult problems; contributes to gaining and discovering new meaning; helps to preserve deep knowledge; maintains high level of digital and technology literacy; improves critical thinking.

Flipped classroom	The method when the teaching content and activities are provided online to the students in advance before they attend the classroom; provides an access and review to mew materials at students' pace; can be implemented through peer-learning when senior or more experienced students assist learning material; creates more active learning; increases motivation.

Source: based on literature review and survey results.

It was found that implementation of innovative teaching strategies depend on teachers' competency and innovative thinking. A teacher always plays an important part in developing mathematical ability among students. Teachers are called the hub of any educational process and the educational program will fail if the quality of teachers is compromised (Sethi, 2021). According to Mondal (2019), a professional teacher who is interested in innovative teaching strategies undergoes advanced training, maintains integrity of educational material, uses interactive techniques, implements ICT extensively, and encourages students.

The findings show that teachers need to take a number of measures to make the educational process more efficient. These measures include:

1) Plan the lesson properly and choose different strategies in the classroom, paying attention to the use of ICT and interactive learning;

2) Make the lesson dynamic not dogmatic, apply game-based approach and play-way activities to teach mathematics skills;

3) Orient students towards future professional activity, train them to be flexible while solving professional tasks and focus upon formation of high level of mathematics skills among students through different techniques and methods;

4) Maintain inter-subject links and provide integration of mathematics into other subjects to build integrated vision of professional activity;

5) Use high-quality bilingual textbooks and teaching-learning materials so that students enable to think and speak about both in their home language/mother tongue and in English;

6) Explain the importance of mathematics for the development of society and India's future including the development of such prospective fields like artificial intelligence, machine learning, and data science, etc.

Thus, the training of future mathematicians in Indian higher educational institutions requires gradual and relevant implementation of innovative teaching strategies in order to make the educational process more efficient and to prepare future specialists to act in changing professional environment. Innovative teaching strategies significantly improve the educational process increasing students' learning outcomes and personal development. At the same time, traditional teaching strategies cannot be completely excluded from mathematics education as they maintain values, moral and social skills maintain national identity and help to educate facture citizens of the country.

Conclusions and Implications

Methodology of mathematics education is a multi-aspect phenomenon, independent, dynamic and complex system of teaching strategies influencing the level of mathematics knowledge and skills as well as ensuring a sufficient level of professional-mathematics skills. The study shows that the selection of appropriate teaching strategies is very important to make the educational process more efficient.

Nowadays there are two categories of teaching strategies in mathematics education: traditional and innovative.

Traditional teaching strategies are still widely used in Indian educational institutions. The findings demonstrate that traditional strategies are the following: exercise and practice, home assignments, analysis and correction of home assignments, oral lectures, written tasks, group work, self-study, supervised study, review, problem solving, chalk and talk method, real time example, panel discussion, laboratory work. However currently traditional teaching strategies show less efficiency and teachers using traditional teaching-learning model face a number of difficulties including preparing a poor lesson plan, different students' abilities and difficulties to assess all the learners Inability to integrate ICT to pedagogy Necessity to incorporate game-based approach and play-way learning, irrelevant features of learning environment and requirement to maintain more balanced classroom environment, change of learning styles, necessity to create encouraging materials for advanced learning.

This fact confirms that currently innovations are essential to present qualitative changes in the system of education. The main purpose of innovative teaching strategies is to make teaching mathematics more interactive as well as effective. Innovations improve methodological approaches, teaching methods or tools, facilitates the educational process. The survey shows that teachers use the following innovative teaching strategies: bilingual education, inter-subject links or integrated approach, mobile learning, microteaching, gamification, ICT, flipped classroom, personalized learning. These strategies improve learning outcomes and mathematics skills among students, affect creativity, communication skills, decision-making, and professional flexibility positively, improve development of creativity, enhance motivation to learning activities, increase interest to professional activity, provide better understanding of materials, form students' professional competency, and contribute to formation of decision-making skills.

It was found that implementation of innovative teaching strategies depend on teachers' competency and innovative thinking. A teacher always plays an important part in developing mathematical ability among students. The study enabled the elaboration of the measures to be taken by mathematics teachers in higher educational institutions in order to make the educational process more efficient.

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