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Systems and Features of Secondary Science Teachers' Professional Development in India, China and Japan: A Comparative Evaluation

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Abstract:

The purpose of the investigation is to study and compare some distinctive characteristics of science teachers' professional development approaches and practices at the secondary level in India, China and Japan. The study followed a qualitative data analysis methodology along with a comparative investigation strategy. Japan has a culture of unique systems of professional development like a mentoring system, on-site and off-site training for novice teachers as well as different professional development activities for mid-career and veteran teachers. The 'lesson study' concept originated and helped in improving science teacher's professional development in Japan. Both China and Japan have implemented several laws and reforms regarding their professional development in a significant way and now these two countries are the forerunner of innovative professional development systems among high achieving countries in PISA tests. The success stories of effective science teaching in China and Japan have been reflected in international science competitions like the Program for International Student Assessment (PISA) and the Trends in International Mathematics and Science Study (TIMSS). Many studies in Indian provinces identified the lack of professional competencies and the deficit of proper science teaching skills of science teachers. No comparative study has been found between India, China and Japan for science teachers' professional development at the secondary level to date which reflects the originality of the study.

Keywords: *Science Teaching Practices, Science Teaching Skills, Professional Development.*

Introduction:

The Organization for Economic Co-operation and Development (OECD), with the help of its macro-level international studies, especially "Teaching and Learning Through International Survey" (TALIS) provide information to achieve sustainable development Goal 4's Target 4. c: "By 2030, substantially increase the supply of qualified teachers, including through international cooperation for teacher training in developing countries, especially least developed countries and small island developing States" (United Nations, 2015).

NEP (2020) pointed out that "The quality of teacher education, recruitment, deployment, service conditions, and empowerment of teachers is not where it should be, and consequently the quality and motivation of teachers does not reach the desired standards" (MHRD, 2020, p.23). Those observations are reflected in the

results of international science competitions like the Program for International Student Assessment(PISA). In PISA 2009, two participating states of India, namely Tamil Nadu and Himachal Pradesh got 72nd and 74th position respectively in science rankings among 74 participating regions and countries throughout the world whereas Japan secured 5th position in the list (OECD, 2010). Surprisingly, India withdrew to participate in subsequent PISAs in 2012, 2015, 2018, and 2022 instead of learning from previous poor performances. Therefore, India could not monitor the trends in the performances of school students in science internationally.

Literature Review:

Comparative studies in education, particularly those examining curriculum development, Professional Development (PD), and pedagogical frameworks, provide unique insights valuable for theory, policy, and practice. Guha and Pramanik (2019) conducted a foundational comparative analysis of the philosophical underpinnings guiding mathematics education in China and India, addressing core questions within the field. Their work examined the influence of various traditional and contemporary philosophical schools in both nations. Building on this, Pramanik and Guha (2019a) specifically compared the development of secondary-level mathematics curricula in China and India. Extending the comparative lens to science education, Nandy and Pramanik (2024) examined and contrasted school science curricula in India and Singapore utilizing qualitative analysis within a comparative framework, reflecting systemic differences and reform trajectories. Pramanik and Guha (2019b) further contributed by comparing secondary-level mathematics textbooks from India's National Council of Educational Research and Training (NCERT) and the West Bengal Board of Secondary Education (WBBSE), analyzing specific textbook features. Complementing these, Ghosh and Pramanik (2024) presented a comparative study of science education frameworks in India and China, highlighting both similarities and contextual differences to yield valuable insights. The analyses of International Mathematics Olympiad performance (Pramanik & Guha, 2019c) revealed contemporary standings among China, the USA, and India. Similarly, Nandy and Pramanik (2025a) systematically compared secondary-level science Olympiad programs across India, Singapore, and the USA. Beyond Olympiads, Pramanik and Guha (2018) examined PD systems for secondary mathematics teachers in China and India. Their study highlighted China's well-established PD structures including a formal promotion system and a robust culture of teacher-led pedagogical research. In contrast, India lacks comparable frameworks for structured career progression and collaborative teaching research,while Nandy and Pramanik (2025b) noted India's science PD emphasizes theorywith routine practice, Singapore employs school-cantered mentoring and incentives, and the USA focuses on Next Generation Science Standards (NGSS)aligned inquiry in student-cantered environments. Together, these comparisons foster synergistic knowledge integration across educational systems**.**

The World Bank Report pointed out that in PISA tests, most of the students from third world countries possess much below OECD standard and competencies in science and mathematics at different levels of schooling (World Bank, 2018).

Sarangapani (n.d.) pointed out three challenges facing Indian school science education.

a) Lack of laboratories and scientific equipment to demonstrate science concepts.

b) Inappropriate number of science teachers having science and mathematics backgrounds at least up to class 12th level in their academic background for teaching at the primary level.

c) Lastly, the science curriculum was not advanced enough to fulfil the multiple needs of the students in the science classroom.

A report as stated by McKinsey "Top performers took professional development inside the classroom" (Barber & Mourshed, 2007, p. 20). Continuous PD (CPD) is the most essential key factor in maintaining the quality of teachers (Mullis et al., 2012).

Chung (2016) stated that a good standard of PD system is essential for pre-service and in-service teachers' training to fulfil the educational objectives of society.

Most of the teachers and principals from OECD economies and countries that participated in TALIS 2018, reported that activities like attending in-service courses, and seminars and teaching with a collaborative approach became very helpful for their PD (OECD, 2019).

Tonga et al. (2019) examined and discussed how the rigorous structures and systems of teachers' PD from PISA achiever countries (viz., China, Estonia, Finland, Japan, & Singapore) were conducive to executing better performances in PISA assessments including science subjects.

Several worldwide studies like Trends in International Mathematics and Science Study (TIMSS), PISA (PISA, 2015), and Teaching and Learning International Survey (TALIS, 2013), etc., well narrated the unique characteristics of Japanese teacher's professional culture along with prosperous academic fame of Japanese students (Isozaki, 2018).

Oshima (1920) pointed out three essential qualities needed for effective teaching (1) appropriate facilities (2) implementation of orders and regulations in a systematic manner and (3) qualified teachers. Oshima's philosophy is still relevant in such a way that prospective teachers should obtain sufficient knowledge from the pre-service program and continue their professional development during the in-service program (Isozaki, 2018).

The survey report of TALIS 2013 (OECD, 2014) showed that Japanese teachers' CPD activities are school-oriented and they spend maximum time in school concerning the other countries worldwide. The higher rate of participation of Japanese teachers was due to the professional practices that existed in Japan as well as the severe alignment of perseverance of teachers to enrich their knowledge and teaching skills through CPD (Ogawa, 2014; Isozaki & Ochi, 2017).

In India, Post-independence teacher education was shaped by the recommendations of several committees and commissions viz. Education Commission (1966), the Chattopadhyay Committee 1983-1985 (MHRD, 1985), the National Policy on Education (NPE 1986/1992), Acharya Ramamurti Committee-1990 (MHRD, 1990), National Curriculum Framework (NCF 2005), Right to Education Act (RTE Act, 2009), NCF for Teacher Education (NCFTE, 2009). The Government of India implemented various initiatives **based on** the recommendations of commissions and committees over time, as previously mentioned. Various recommendations related to PD of secondary teachers are summarized in Figure 1.

Secondary Education Commission (1952-1953): A number of institutions as well as agencies were created for operating in-service teachers' training activities.

Education Commission (1964-66): 'School Complexes' were established to enrich teacher's work in school. The 'State Institute of Education' (SIE) was established for in-service training.

NPE – 1986: District Institute for Education and Training (DIET) in every district, Colleges of Teacher Education (CTEs), and Institutes of Advanced Studies in Education (IASE) were established for in-service teacher education. Programme of Mass Orientation of School Teachers (PMOST), and Special Orientation Programme for Primary Teachers (SOPT) were launched to impart training for primary and secondary teachers using the 'cascade model'.

SSA (2001): Block Resource Centres (BRCs) and Cluster Resource Centres (CRCs) were constructed to conduct in-service teachers' training with the purview of UEE (MHRD, 2004).

Rashtriya Madhyamik Shiksha Abhiyan (RMSA, 2009): RMSA focused on conducting in-service teacher training programs for science and mathematics teachers to improve the quality of the teaching-learning process in secondary education (GOI, 2009).

Samagra Shiksha (2018-19): One of the key objectives of Samagra Shiksha initiative for improving the standard of education was to strengthen and upgradation of the SCERTs/ state institutions and DIETs and functioning as nodal agencies for teachers' training. According to this initiative, PD training programmes for secondary and senior secondary teachers have been scheduled in a calendar year at the SCERTs and DIETs (DSEL, 2021). For this purpose, National Initiatives for School Heads' and Teachers' Holistic Advancement (NISTHA), NISTHA 1.0 (Elementary Level), NISTHA 2.0 (Secondary Level), NISTHA 3.0 (FLN for NIPUN Bharat, online NISTHA) were came into effect under Samagra Siksha Initiative (Suter, 2022).

NCFTE 2009: The content and method of in-service training were jointly designed by SCERTs and IASEs. IASEs had the main responsibilities of conducting training programs for in-service secondary teachers in addition to PD of secondary and primary teachers and secondary teacher educators.

NEP 2020: The latest education policy suggested that teachers have to take a minimum of fifty hours of CPD activities in a year. CPD will be provided according to the teacher's interest and autonomy through various modes like seminar presentations, workshops, online teacher development modules, etc. (NCERT, 2022).

Figure 1: Secondary teachers' PD related recommendations given by various commissions / NEPs

Prabhu (2012) mentioned four types of activities that help escalate teachers' professional improvement- (i) having minute observation of other's live or video-recorded teaching. (ii) pedagogic design should be according to the classroom requirement at a certain time. (iii) transferring the teacher's pedagogic understanding to the fellow teacher. (iv) discussing a teacher's pedagogic perception with a specialist in a specific field.

Villegas-Reimers (2003, p.12) mentioned that ' In-service training' and ' career development' are mainly organized programs for teachers' professional growth and those programs are mainly workshops or short-

duration courses regarding innovations of the teaching-learning process. While CPD is a continuing process, where teaching related to various suitability and competencies are planned systematically and provided regularly to the teachers to improve their professional growth and development.

OECD (2019) stated that "Continuous professional development is a vital element of the career path of teachers and principals, providing training that can affect both classroom and school practices". Sahu (2016) found that science secondary teachers in Odisha were not taking the help of innovative ways of teaching in science classrooms. He pointed out the lack of competencies among the science teachers. Tron (2018) supported this fact and pointed out that most of the science teachers were using conventional methods such as lecture methods and demonstration methods but they do not use laboratory method and hands-on activity approaches for teaching science topics in the secondary schools of Meghalaya.Remya and Chevan (2022) found out the current scenario of science education in Palghar district schools of Maharashtra and pointed out that in most of the science classes lecture method is still followed even in the 21st century modern technological era.

The result of the National Achievement Survey (NAS-2017) (MHRD, 2019) and other research findings revealed the necessity of improving the teaching-learning quality in Indian schools. NEP (2020) suggested the emergence of supporting teachers' PD facilities continuously. Therefore, the emerging idea of CPD in India may fulfil the lacuna of teachers' understanding due to existing inappropriate standards of pre-service teacher education.Monika and Lal (2019) found that most of the Indian science teachers' regular science teaching activities were not according to NCF 2005. The reasons behind this are some barriers like large class sizes, shortage of time, giving excessive importance on the results of board examinations so the teaching-learning process runs wisely, and many more. The authors' concern was how the findings of this study will be important for improving secondary science teachers' PD activities by overcoming the possible barriers.

Research Gap:

There are no comparative studies of secondary science teachers' PD activities between India, China and Japan until date. The study has focused on filling that gap.

Objectives:

i. To study the systems and features of science teachers' PD prevalent in India, China and Japan at the secondary level.

ii. To analyse the systems and characteristics of science teachers' PD of the three countries comparatively.

Methodology:

General methodology: Qualitative study,

Methodology: Few-country comparison,

Comparative method: Case-oriented studies, Document analysis, Content analysis

Research materials: Government documents, books, edited books, Ph.D. thesis, newspapers, conference papers, peer reviewed journals

Data collection process:Multiple procedures consisting of studying journals (print and online both), books, newspapers, and periodicals have been used.

Data analysis:The study has employed the document-based analytical approach. To analyse the collected data historical and sociological strategies have been adopted.

Characteristics and systems of PD of school science teachers:

Indian context:

In India, teacher education policy has developed gradually based on the reports published by various commissions and committees such as the Kothari Commission (1964-66), the Chattopadhyay Committee (1985), NPE-1986 & 1992, Acharya Ramamurti Committee (1993), NCF-2005, RTE Act-2009 and many more. Recommendations by those commissions and committees play an important role in shaping the PD of Indian teachers.

Following NPE-1986, the National Council of Educational Research and Training (NCERT) and Regional Institutes of Education (RIEs) were set up and institutions organized a number of training programmes to improve in-service teacher education for primary and secondary teachers' competency along with the fulfilment of other objectives.

RIEs provide PD activities for school science teachers. National University on Educational Planning and Administration (NUEPA) offers support for running successful PD activities.

State Council of Educational Research and Training (SCERT), as a state level apex organization, offers PD activities for science teachers by organizing various activities like workshops, training programs etc.."Colleges of Teacher Education (CTEs)" and "Institutes for Advanced Learning in Education (IASEs)" organizes workshops, seminars and training programs in which school science teachers can develop their professional competencies (NCFTE, 2009).

In the current scenario, Indian school science teachers still remain deprived from proper PD programs and activities due to lack of proper coordination between the organizer of the programs and head of the schools. As there is no law related to PD in India, the success of PD training programs totally depends on teachers' interest, motivation and willingness to take part in the programs.

According to the suggestions of NEP 2020 (MHRD, 2020), NCERT has proposed and framed a guideline for CPD for teachers and head teachers. In this guideline, it has been proposed that teachers should engage in the programs and activities according to their choices, needs and time-schedule. The focus will be nurturing science teachers' hands on experiences through community participation. Teachers have to maintain e-portfolio through which they can be able to analyse their teaching skills, setting goals and objectives wisely. This portfolio will be connected to teacher's Career Management and Progression (CMP) and National Professional Standards for Teachers (NPST). Teachers will update their e-portfolio after obtaining certificates or producing evidences of completion of fifty hours of CPD programme. Finally, the e-portfolio will be analysed by concerned upper authority like head teacher, CRCC, BRCC, DIET, principal of CTE/ IASE (NCERT, 2022).

System and features of PD of science teachers inChinese context:

Some of the important feature of PD for Chinese science teachers are—

- **Teaching Career Hierarchy (i.e. ranking system) and Promotion System of In-service Teachers:**

In mainland China, when a candidate with Bachelor of Science degree (UG) or Master of Science degree (PG) is appointed as a secondary science teacher will get " junior rank" after completion of three years of

teaching (with bachelor degree) or upon completion of one year of teaching (with PG degree). A junior ranking teacher will get the "intermediate rank" after lot of teaching experience as well as earning and adding several credit points from in-service PD programs every year like taking part in teaching proficiency contestation and investigating few problems, they have faced during classroom teaching. To obtain the " senior rank" a science teacher must possess in-depth of science content knowledge, clear perception of pedagogical concept, ability to conduct a science teaching research program successfully and may have contribute to train the lower ranking teaches. To obtain the honorary title of the highest ranking i.e. "master teaching rank", a teacher must possess crystal clear knowledge of science subject as well as clear concept of educational theory and practices in K-12 classes. He/ She must be able to start and conduct research programs successfully, has to publish a significant number of papers in Chinese language in the journal related to science teaching articles. He/she must have supports from the fellow teachers and must play the crucial role to train the below ranked teachers (Liu & Liu, 2017). The ranking hierarchy of secondary teachers are shown in Figure (2).

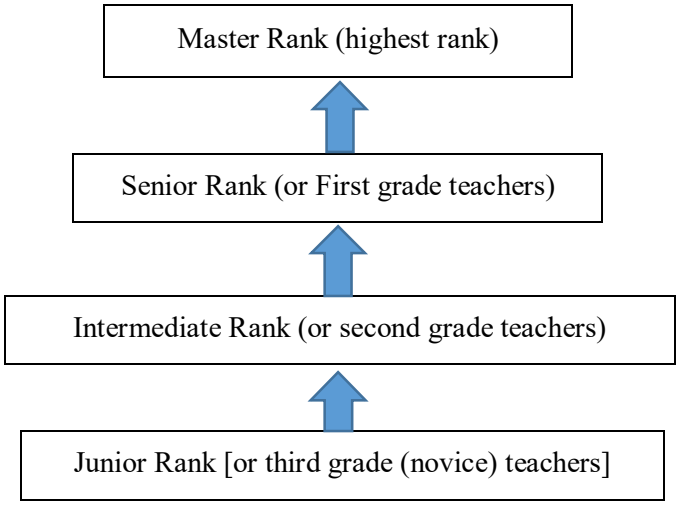

Figure 2: Ranking hierarchy of secondary teachers in China:

- **One-to-one Mentoring for novice teachers:**

Teacher mentoring system for newly appointed (novice) teachers was a key feature of teacher training of PD programs in Shanghai and rest part of China (Pramanik & Guha, 2018).

One-to-one mentoring teaching practice for novice teacher of their initial two to three years teaching period have been observed in China, where generally a legal agreement is signed between a mentor and a mentee (Huang et al., 2010; Pramanik, 2019).

- **Workshop Programs for Distinguished Teachers**:

This PD program was modelled for the teachers who have significant contribution either at school level or in the school district level (Pramanik, 2019).

- **Mechanistic structure of teachers' training program for PD:**

Chinese teachers' training programs are highly mechanistic and mainly controlled and governed by central government (Jones, 2003) and all the training institutions are supervised and controlled by following vertically top-down hierarchical mechanism (Ke et al., 2019; Pramanik, 2019).

➢ **Guiding Principle of Teacher Education:**

In 2002, China's teacher education program was modelled by following the principle of lifelong learning theory. The structure was aligned to the three stages of teachers' PD viz. pre-service training, on-the-job training at the initial stage of teaching and in-service training for all teachers including secondary science teachers (Xiaodang, 2008).

➢ **Five levels of teaching research system:**

The five levels of teaching research system was introduced in China in the 1950s period (Yin et al., 2020) and the hierarchical levels of teaching research system (Zhang, 2023) is shown in Figure 3.

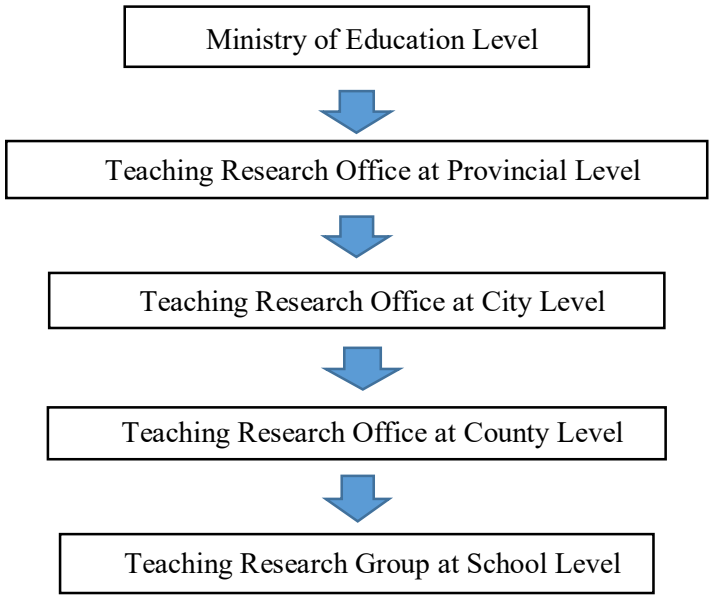

Figure 3: Hierarchical Levels of Teaching Research System in China

Lin (2019) discussed China's Science Teachers' Professional Development (STPD) in three stages-

Stage 1: The starting phase of STPD in mainland China: During this stage different initiatives have been taken for STPD such as

- Preparation of collective lesson.
- Organizing various teaching competitions.

Preparation of collective lesson:

Preservice and in- service science teacher's education was organized in different way for a long period in China (Lin, 2015, p.58-62).

For pre-service teachers' preparation, normal universities have the main role focusing on science subject knowledge with one to two months of practical teaching experiences in educational institution. Those new teachers were called as "semi-finished products". On the other hand, newly appointed teacher's initial training as well as further in-service trainings were organized and controlled by the local teaching and research institute. The focus of those institutes were to prepare collective lesson by the full time Teaching Research Staff (TRS). TRSs were responsible for providing training and to improve teacher's working in a collaborative way (Cong, 2011, p.151-165). Some important teaching strategies as recommended through

collective lesson formulation activities were lecture method with something demonstrating science experiments, graph papers, models (Lin, 2013a, 2013b; Qiao et al., 2017).

Organizing various teaching competitions:

National teaching associations for science teachers was established by TRS for improving the teaching quality in science classrooms (Cong, 2011, p.265-276).

The association conduct teaching competitions every year to motivate science teachers to go through the curriculum and to improve their teaching techniques as well as creating opportunities for observing a huge number of quality classroom teaching taught by other science teachers took part in those competitions(Cong, 2011, p.265-276).

Stage II: The developmental phase of STPD in mainland China:

Scientific inquiry based teaching: After 2001, China has implemented new curriculum where along with changes in curricular goals i.e. scientific literacy became the focus (Lin, 2002). Science teachers were also directed to follow the inquiry based teaching strictly, which reflects the nature of science (Liu et al., 2012)

In-service science teachers' knowledge updating through correspondence education: Junior college programs, bachelors programs and postgraduate programs were started by normal universities through distance mode (Guan, 2012, p.88-95). In-service science teachers get an opportunity to acquainted with the new scientific concepts and be able to apply modern scientific instruments and technologies for demonstration of science experiments (Guan, 2012, p.89).

New curriculum related trainings helped science teachers' cognitive change:

Outstanding TRS and teachers were given national level training for new curriculum and subsequently known as seed teacher. Seed teachers after returning to the provinces helped the provincial TRS to give training to the selected municipal level teachers. Consequently those teachers went back to cities and towns to help municipal level TRS in organizing training for mass number of local teachers to cope up with the new curriculum and teach accordingly (Liang et al., 2011, p.188-197). The stepwise teachers' training process is shown in Figure 4.

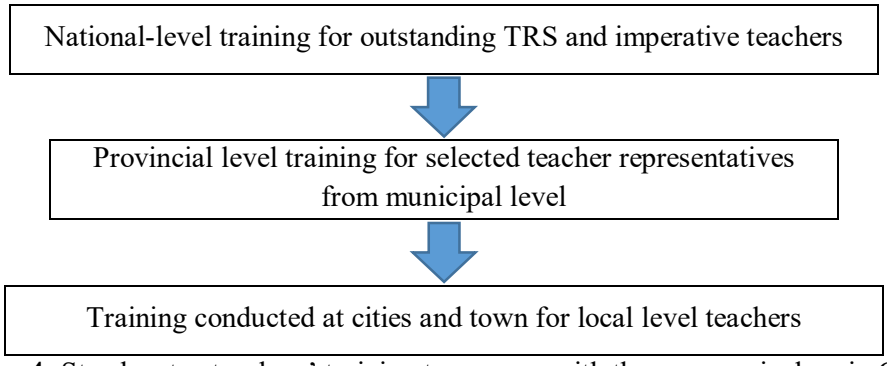

Figure 4: Step by step teachers' training to cope up with the new curriculum in China

Stage III: The final phase or recent developments of STPD in mainland China:

In 2015, MOE conducted a quality assessment for compulsory education to investigate student's academic outcome to observe their physical and mental health status as well as to explore the key factors influencing the quality of education (MOE, 2015). This assessment envisaged for improving teaching learning atmosphere in schools (MOE, 2018). In 2017, MOE approved new curriculum focusing on core

competencies. The new guidelines and standards instructed the science teachers to become science education researchers where they will analyse their daily classroom teaching practices (Lin, 2019). For this purpose teaching research groups have formed at the school level and these groups are categorized into three sub-groups (Zhang, 2023) as shown in Figure 5.

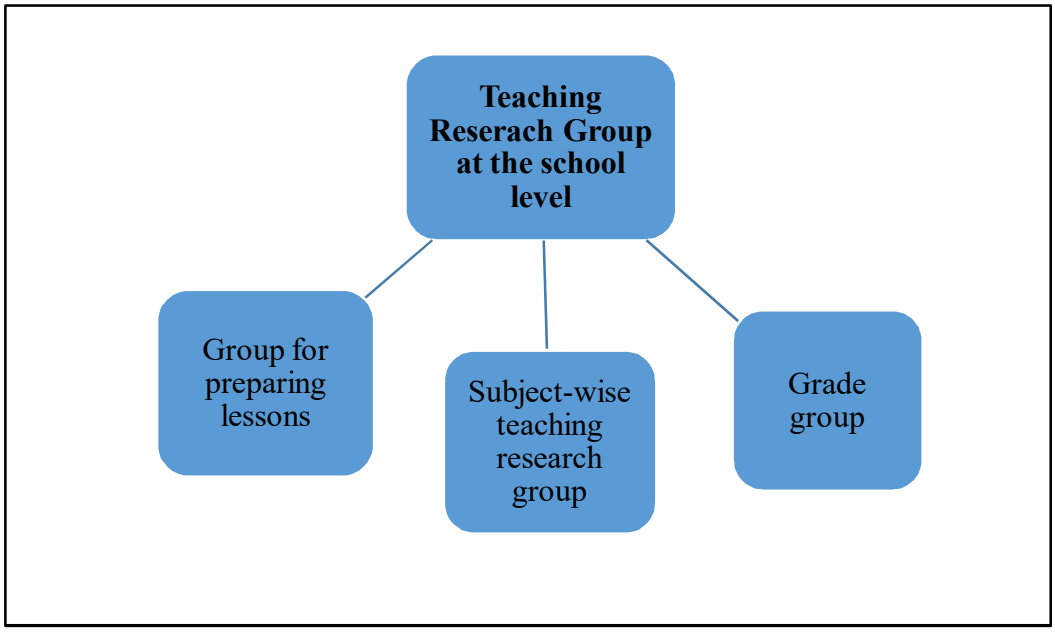

Figure 5: School-level Teaching Research Group in China

Collaborative research activities between school science teachers and university teachers:

Science teachers should work like researchers and for this purpose they should be given support to do research about their daily teaching practices in a collaborative way with university professors (Bu and Hun, 2019; Zhang and Sun,2018; Qiao et al. 2017). In this collaborative research process, strong theoretical knowledge of professors from universities and science teacher's huge classroom teaching experiences collectively creates an effective way of science teaching and hence improving PD (Qiao et al. 2017).

Flourishing science teachers' teaching skill assessment outcomes published nationally:

The schools as well as teachers have assessed and supervised by the teaching and research institute for the past few decades (Cong, 2011, p. 201-224). National science assessment report helped science teachers to become systematic researchers and develop their teaching skills through their daily practices.

Developing open and parallel lesson study:

China developed 'open lesson study' and 'parallel lesson study' those were very helpful for improving science teaching competencies of school teachers and so their PD also (Huang et al. 2010).

Model lesson study: China developed a unique kind of PD workshop. In this model lesson study approach, an experienced senior ranked subject teacher is appointed as 'subject coordinator' in every school district. Science subject coordinator recognizes either a senior or a newly appointed teacher with innovative ideas of teaching with a model lesson. All the science teachers from the school district (including the selected teacher with his model lesson) are invited to participate and observe the demonstration teaching according to the model lesson. The subject coordinator as well as the teachers present at the workshop suggested if any modification needed. Finally, this model lesson is executed at provincial or national level conferences.

Therefore, these innovative ideas of science teaching are spread throughout provinces, cities or all over the country (Liu & Liu, 2017).

A sample schedule of different phases and the activities of teachers in China are described in Table 1.

Table 1: Sample schedule and activities for distinguished teachers at Haidian Teachers' Academy

Sessions / Phases with duration	**Assignments/ Activities**
1st Phase: Producing plan by self and participating in various activities. 6 months duration.	At first teacher participants, produce their PD oriented self- ideas to their peers and mentors. After that the teacher participants will get an access for a huge number of workshops and activities like book reviewing, "model lesson study" etc. Finally, teachers have to produce a specific frame of PD plans for their own by clearly mentioning what they want to achieve and by what process.
2nd Phase: Executing their self-made PD plan by framing and applying collaborative science education research. 24 months of duration.	Teachers have to continue the activities as mentioned in the previous phase i.e. book reviewing, lesson study etc. Eventually, after a serious discussion with the other participants, teachers discover a path for how to work together on the topic selected by them.
3rd Phase: Briefing and Reflexion	Teachers scripted and proclaimed their success stories and findings within other participants how to start PD plans and execute them in different levels viz. school level or school district level.

System and features of PD of science teachers inJapan

- **Various aspects of educational philosophy of teacher education**

In Japan, the idea of "education as a craft" is deeply rooted in their educational philosophy and organized teaching learning practices. Various aspects of Educational philosophy are as following (Badawi & Badawi, 2024)-

- **Observing the adherence of mastery:**

  To deliver quality education Japanese teachers continuously try to develop their knowledge and skills.

- **Cultural values:** The philosophy of "shokunin" that means craftsmanship delivers the quality of teachers like passion, engagement to the profession and devotion to achieve their perfection in teaching.

- **Prioritize on individualized learning:** In addition to group learning, teachers focus on individualized learning of the students according to their capacity and pace.

- **Integrating traditional and modern innovative methods:** Teachers always try to balance between traditional and innovative methods of teaching to deliver quality education.

- **Preparing appropriate lesson plans and executes them:** Teachers prepare classroom situation appropriate lesson plan and execute those with the help of teaching learning materials and suitable methodologies.

- **CPD of teachers:** Japanese philosophy of education always caters for teachers' training and PD of teachers with peer learning and rigorous practices throughout the teaching career.

➢ **Types of teaching certificates:**

There are three types of teaching certificates existed in Japan as shown in the Figure 6.

A) 'Regular teaching certificate' issued by the Prefectural Board of Education upon completion of training program and this is valid throughout the country and these regular teaching certificates are categorized into three types as Advanced, Type I and Type II (Numano, 2011; Yamasaki, 2016).

B) 'Special teaching certificates' are issued to the person with ample knowledge, teaching skill, social recognition and futuristic insight of education, after interview by the specialists. This type of certificates are valid only within a specific prefecture (Yamasaki, 2016; Kaur and Sharma, 2019).

C) 'Temporary teaching certificate' or Provisional certificate is issued for a specific prefecture when there is a problem for issuing regular certificate. This is valid for three years only (Numano, 2011).

➢ **Categorization of teachers and their PD requirements**

Teachers are classified into two categories and their PD requirements are shown in Table2.

Table 2: Categorisation of teachers and their PD requirements in Japan

Teacher's Category	**PD requirements**
Beginning Teachers: Teachers recruited at the local school for first six years (Ahn et al., 2018). During this period, they are treated as beginning or novice teachers.	❖ Novice teachers have to go through on site as well as off-site trainings. ❖ On-site PD training of novice teachers are mainly induction i.e. observing classroom teaching of mentor teachers by novice teachers and vice versa. ❖ Total duration of on-site and off-site PD training will be three hundred hours per year in which at least twenty-five days of off-site activities must be included (Ichikawa, 2015; OECD, 2016a; Ahn et al., 2018). ❖ In addition to these requirements, some local governments such as Osaka city mandates for 5th year teachers to acquire extra professional knowledge and skills for becoming a mentor (Osaka City Education Center, 2018; Ahn et al., 2018).
Mid-career and Veteran teachers: Teachers having 10 years of continuous teaching experiences	• At least twenty eight days PD activities (eleven days off-site and seventeen days on-site training) during 10th year in-service training have to be performed by the mid-career teachers (MEXT,2017a). • On-site PD activities of science teachers include science teaching skills,

are regarded as mid-career teachers.	current educational contents, lesson study and most importantly communication with the school principal and vice principal through conference (MEXT,2017a). • Off-site PD activities of science teachers include lectures on science subject teaching, discipline related issues of students, knowledge of technological instruments and their application in science teaching, concerns of environmental issues etc. (MEXT, 2002). • Teachers' room of Japan's schools set the success story of teachers' professional growth. In such teachers' room, highly experienced (veteran) teachers willingly take responsibilities of less experienced teachers for their professional growth through collegial learning environment (Ahn et al., 2018).

➢ **System of Teachers' Training and Teaching Certificationin Japan:**

Principle of open teachers' training is shown in Figure (6)

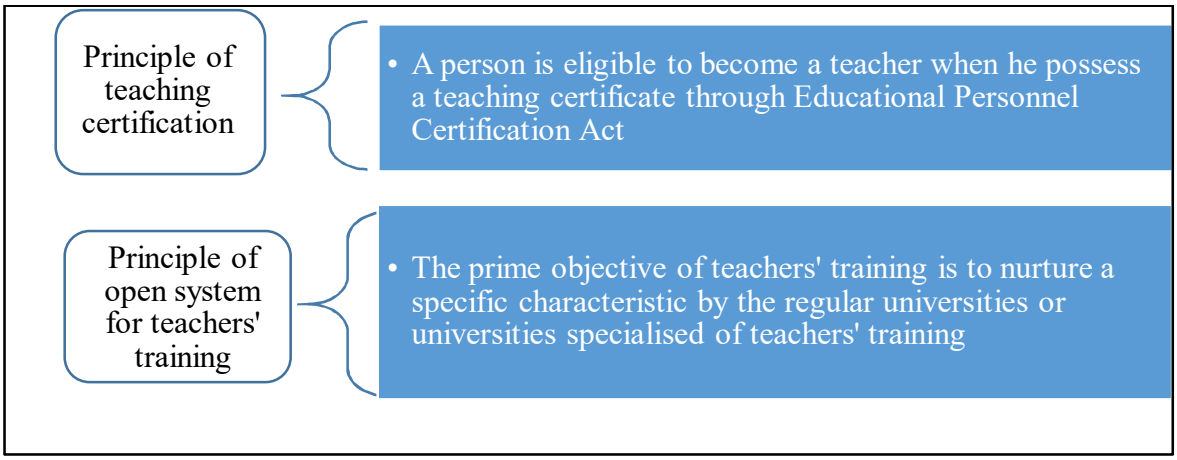

Figure 6: Principle of teaching certification and principle of open system for teachers' training in Japan (MEXT, 2012)

Types of teaching certificates and their eligibility criteria in Japan are shown in Figure 7**.**

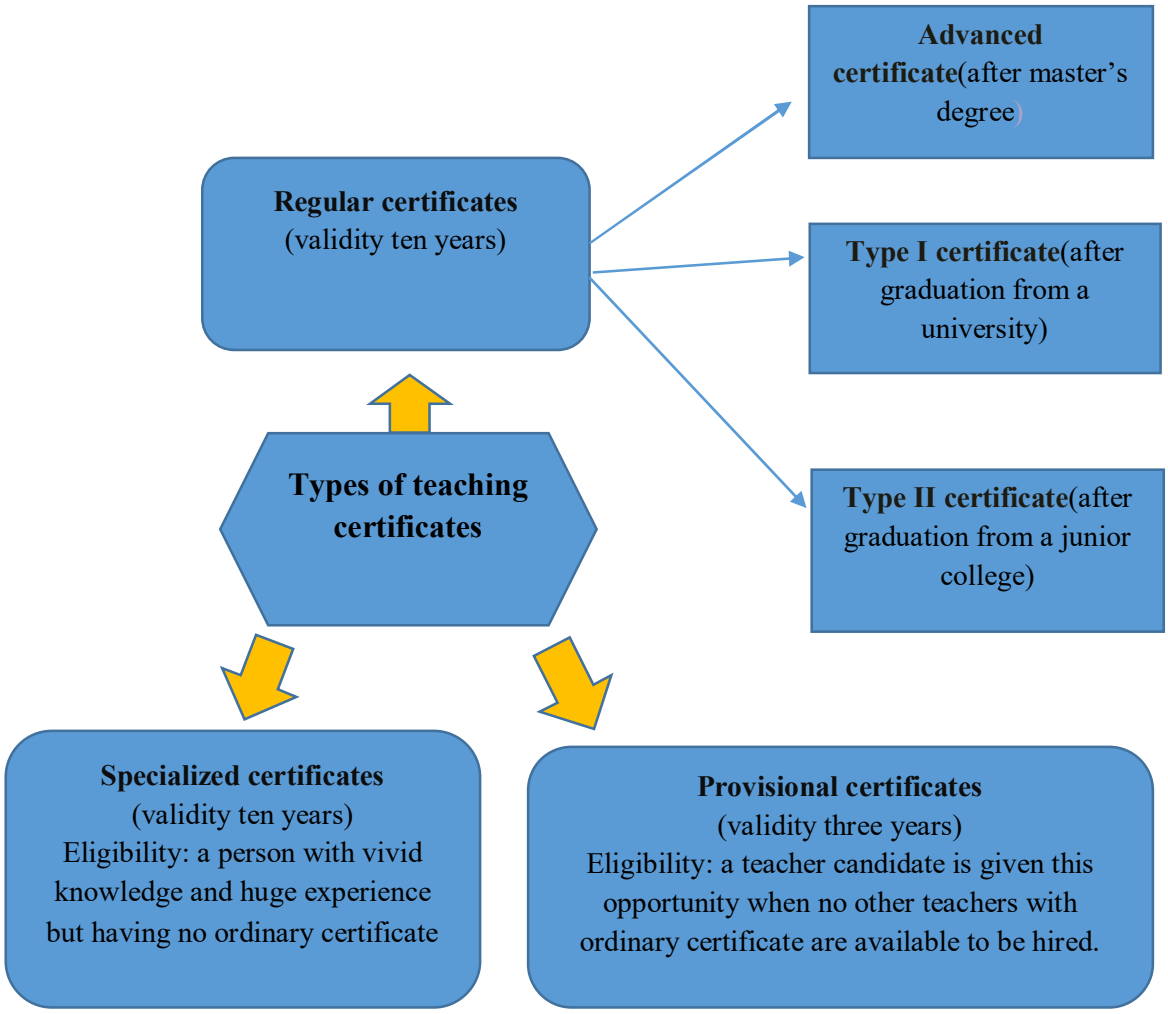

Figure 7: Types of teaching certificates and their eligibility criteria existing in Japan

Mentoring System in Japan: Newly appointed teachers get full support from all the teaching staff of the school and they receive one year of mandatory in-service educational training. In this training program, they have to go through sixty days of in-school training from an expert senior teacher (like a mentor) and thirty days of off-school training. General activities of this training includes analysing lesson plans, making teaching materials from available resources, observing one other's teaching, exchanging suggestions for modification, self-thinking on the suggestions for modifications and constructing plan for overall school activities (OECD, 2016a).

Lesson Study in Japan: Japanese lesson study is neither entrusted nor compulsory, but actually, it is a teacher-initiated comprehensive process of researching their daily teaching in school societies through exploration (Doig & Groves, 2011).

Lesson Study Process in Japan: The process of lesson study originated from a tactic to prepare lesson plans with inquiry approach and the concept of continuing education throughout life (Akita & Sakamato, 2015).

Isozaki (2013) explained the science subjects' lesson study as three sections. First section describes the preparation of science lesson study, which involves defining the problems and fixing the topic with its goals

by science teachers in a collaborative way. In the next section, science teacher teaches research lessons in their classroom as well as in laboratories with the active involvement of students in science practical activities. Most of the time science teacher teaches their research lesson with the help of inquiry-based teaching-learning method. This method of teaching enables students to make a hypothesis, engage in laboratory work, collect data, and generalize their observations. The final section of the lesson study is post lesson contemplative discussion. External advisors observe teaching of the research lesson, make comments, and give suggestions for further improvement of the lesson.

Lesson Study and PD of science teachers in Japan:

Teachers can develop their teaching skill by thinking deeply and differently about teaching approaches through research lessons (Doig & Groves, 2011). Lewis & Tsuchida (1999) stated that lesson study plays a vital role to propagate concepts about new contents and pedagogical approaches at the time of curriculum changes nationally. By the lesson study, teachers able to visualize the demonstration teaching and can modelled their teaching according to the changed contents and pedagogy.

Japanese science teacher's professional growth depends not only on lesson study but also on regular school activities. Science teachers frequently discuss about various scientific and educational issues, this type of thoughtful conversations among them become helpful in Continuous Professional Development (Isozaki, 2015).

Various PD trainings conducted mainly two levels viz. national level and local level for teachers, instructors and educational personnel are shown in Figure 8.

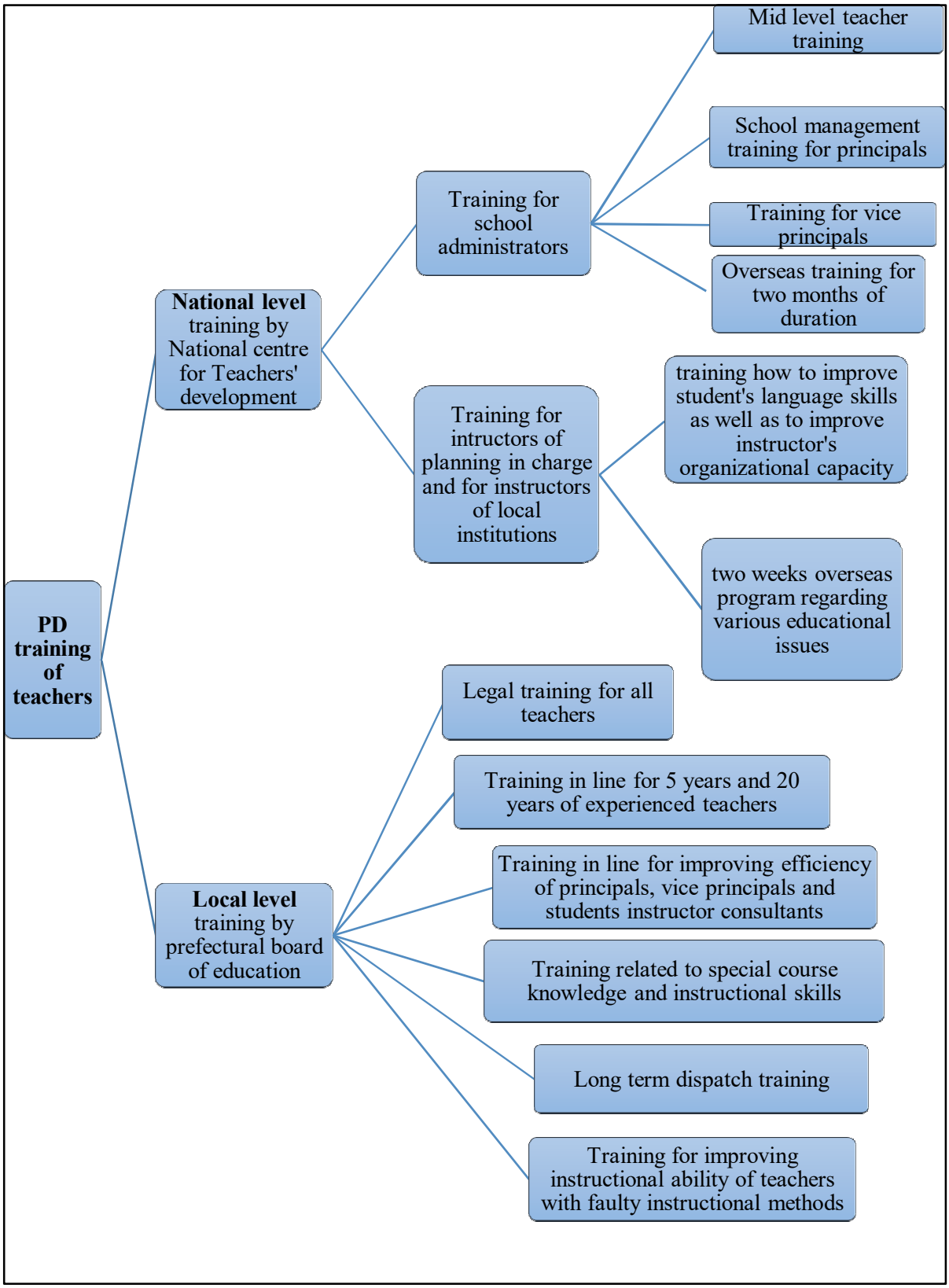

Figure 8: Various PD training conducted in Japan (Source Yamasaki, 2016; Kaur & Sharma, 2019)

Comparative analysis:

Comparison of PD laws or acts for in-service teachers is shown in Table 3.

Table 3: comparison of acts/ laws of PD between three countries

India	China	Japan
Since independence, Govt. of India has taken many initiatives and organized various programs for in-service teachers following different commission and committee's recommendations. Actually, India does not have any Acts of PD for in-service teachers including science teachers. Very recently, NEP-2020 recommended for at least fifty hours of CPD activities for in-service teachers in a year.	According to Article 35 of China, State is responsible for appointing teachers and improving their quality through various trainings, examinations and rewards. China has implemented the Teacher's Law in 1994. According to this law, in-service teacher has to do at least two hundred and forty hours of PD activities within every five years of time of teaching career (Leong et al., 2017). In 1999, MOE, China, issued the regulations of lifelong education applicable for primary and secondary teachers. Newly appointed teachers have to take at least one hundred and fifty periods of training in addition to at least two hundred and forty periods of job training within every five years of teaching period. Where one period indicates forty-five minutes to one hour of learning time (Gang & Meilu, 2007).	In 1989, MEXT introduced a policy on induction for newly appointed teachers who have to complete at least three hundred hours in a year (on an average of ten hours /week) of PD through both on-site and off-site training activities (MEXT, 2009). In 2003, MEXT inducted another law of 10th year PD to create leadership characteristics among teachers of their mid of the career. Teachers have to spend an at least eleven days off-site (total of twenty-eight days) PD activities (MEXT, 2017a). In 2009, MEXT introduced compulsory renewal of a teacher's license at the interval of every ten years completion of teaching career (Akiba, 2013; MEXT, 2017b).

Comparison related to PD systems:

1. Most of the PD programs in India, China and Japan are funded by MOE of the respective central governments preferably.

2. Value-based PD in all the countries has been observed for preparing 21st century enabled classroom.

3. Chinese teachers are expected to participate in three hundred sixty hours of CPD activities every five years (OECD, 2016b) and this is mandatory requirement to renew the teaching certificate in every five years interval (NCEE, 2023). Japanese teachers have to take part minimum of thirty hours of formal professional development activities for renewing their teaching certificates in every ten years (NCEE, 2023). Whereas in India, there is no such criteria of teaching certificate and mandatory PD as well but recently NEP 2020 proposed for Indian teachers to take fifty hours of CPD in a year.

4. In China (Shanghai) mostly offline PD activities are feasible but there is also a web platform from which teachers can access various resources like curriculum concepts, research papers etc. related to teaching (NCEE, 2023), recently online PD has been expanded and become very popular. In Japan,

mainly offline (face-to-face) PD activities are followed, whereas in India mainly online activities are followed.

5. In India, PD programs/trainings are practiced in a diplomatic way as well as irregular manner, while both in China and Japan PD is considered as mandatory duty which should be carried continuously throughout the teaching career.

6. In China and Japan, on completion of specific PD requirements teachers get renewed teaching certificate and secure their teaching position and promotion have been awarded to teachers accordingly, whereas in India, there is neither teaching certification system nor promotion system present.

7. By law as well as for improving teaching quality throughout the nation both China and Japan have designed and implemented PD framework which are also globally accepted and followed by different countries. Whereas India's PD system is not uniform and not up to the global standard like China and Japan.

8. Chinese and Japanese teacher's participation rate in PD programs and activities is very high among high performing countries in PISA tests (OECD, 2014; NCEE, 2023).

9. In China and Japan, collaborative activities between science teachers within a school and from neighbouring schools as well as publication of teaching research lesson are the important part of teacher's PD. Such activities are not feasible in India.

10. In India, mainly informal approach with less importance on formal approach is given for PD, whereas in China and Japan both formal and informal PD approaches get equal importance.

11. China's PD activities are mostly school oriented involving top-down PD trainings in addition to teacher led and collaborative activities (such as preparing collaborative plan by discussing within science subject specialist Teaching Research Group, producing open lessons and evaluating it by the peer groups and research on daily teaching activities) (Chen, 2020; Ke et al., 2019; OECD, 2016b; Thomas, 2020). Japan's PD activities involves courses and workshops (Mullis et al., 2012) mentoring system (Tonga et al., 2019) and lesson study. In India, there exist top-down PD training programs but no teacher-led collaborative activities, mentoring system or lesson study approach.

Conclusions:

The present comparative study discussed about the secondary science teachers' education and PD system prevailing in India, China and Japan. This study reflects that how China and Japan have taken many initiatives to overcome their lack of teachers mainly in the rural areas. Both China and Japan have implemented several laws and reforms regarding their PD in a significant way and now these two countries are the forerunner of innovative PD systems among high achieving countries in PISA tests. China and Japan have move their top-down PD training approach to teacher-led PD approach and PD activities are mainly school based. Chinese and Japanese teachers through lesson study gather theoretical knowledge as well as practical experiences. Whereas in India PD programs are top-down trainings those are limited to enhance theoretical knowledge only. One of the important feature mentoring system is very much helpful for secondary science novice teachers in China and Japan. India should adopt this approach for their newly recruited teachers. Ranking and promotion system in China and Japan help their senior teachers keeping updated and skilful throughout their teaching career. Recently NEP 2020 suggested for several changes in the teacher education and PD requirements which may be helpful for shaping the teacher education and PD

system including secondary science teachers aligned with the 21st century teaching skills like China and Japan those have already achieved.

This study is limited in exploring the contemporary PD system existed in India, China and Japan. Only secondary science teachers in government and government-aided schools are considered here. Therefore, in future such type of study may be done in other countries and in primary and higher education levels.

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