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Review Article

Chemical Education in India in line with New Education Policy, 2020: Scopes, Issues and Challenges

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ABSTRACT

India has implemented a newly frame-worked National Policy on Education in short NEP-2020 and based on this new policy, a student centric Chemical Education in terms of 4-year Undergraduate (UG) Program (FYUP) has been employed from the session 2023–2024. The main goal of the FYUP is to provide a multidisciplinary curriculum offering a better program focusing on providing high-quality teaching-learning, research, and engagement of our society with no hard separation among the existing different streams of education. The various reputed universities of various countries are allowed to establish campuses and provide higher education in India. This article focuses on new system Chemical Education in India in terms of the FYUP with special emphasis on Higher Education in India and subsequent postgraduate frame-work which are designed in line with NEP. The challenges of the 4-year UG program and subsequent quality education, the other scopes in Chemical education and the career opportunities thereafter are discussed in detail along with various job opportunities.

Key words: Chemical education, FYUP, Higher education, India, NEP-2020.

1. INTRODUCTION

India, with its rapidly growing economy and the world's largest young population, is among the fastest-growing nations globally. Although the world is experiencing rapid changes in the education system with rapid science and technology, India was following an Education Policy which was 34 years old that primarily emphases on primary education system in our Country (Pandey, 2019). The traditional teacher-centric methods of teaching and learning have poor impact in today's 21st century students with the advancement of technology. In present day, context to learn and think differently with the utilization of information and technology is more important than simply knowing things (Aragwal, 2009). The Indian Ministry of Education lists 165 Institutes of National Importance (INI) that significantly contribute to the teaching and skill development of India's highly skilled students. (INI, MoE, 2022). INI status has been granted to several specialized colleges/universities, including the Indian Institute of Technologies, National Institute of Technologies, Indian Institute of Science (IISC), and IISC Education and Research. The government funds, recognizes, and supervises these institutes, universities, and colleges to establish learning centers in academics and research. But after 2020, a new education policy named National Policy on Education is going to be implemented from the session 2023-2024. This National Policy on Education in short NEP-2020 aligns with the United Nations Agenda for Sustainable Development Goal no. 4, promoting global educational development, adopted by India in 2015 (NEP, 2020). The NEP-2020 aims to guarantee quality education that is inclusive and equitable, and to foster lifelong learning opportunities for all by 2030. It also emphasizes the importance of quality education in terms of better gross enrollment ratio, teaching-learning outcomes, and program-based skills-oriented education for youth. India's unemployment rate reached 11% in 2019, with over 30% of unemployed youth possessing bachelor's and master's degrees (KPMG, 2019). Therefore, Indian higher education system particularly in Chemical Education requires major reforms to create more opportunities for the young minds. Based on the NEP-2020, a 4-year Undergraduate (UG) Program in short FYUP will be launched across India very soon. In fact, the FYUP has been adopted by almost all higher educational institutions in India from the academic year 2023–24. The most of the reputed Universities have already notified about the Common University Entrance Examination (UG) for admission to FYUP courses. In line with the NEP-2020, the new FYUP aims at not only to award degrees but also focus on imparting degrees as well as life skills and vocational courses of the students. The FYUP is a student centric approach where students will have capabilities and accessibility and students will have the maximum knowledge of education beyond traditional education. FYUP aims to provide a superior Chemical Educational program through a multidisciplinary curriculum that includes high-quality teaching-learning, research, and community engagement. It will award students degrees in various disciplines of Science, Arts, Humanities, Sports, and other vocational subjects with increased flexibility as well as complete academic and theoretical knowledge and with subject choice (UGC, 2023). The NEP-2020 introduced significant reforms aimed at modernizing India's existing education system. The NEP-2020 proposes a 5+3+3+4 system of schooling, which includes a

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foundation stage for early childhood care and getting education from the age of 3 years. It aimed at promoting a better learning, development, and well-being of the child that ensures early childhood continuum as shown in [Figure 1]. Accordingly, the UG and postgraduate (PG) degree will be of either 3 or 4-year duration with multiple exit options.

Keeping this in mind, in this article, the Chemistry Education in India based on the FYUP and subsequent PG frame-work which are designed in line with NEP is discussed and analyzed in details. The challenges of the FYUP and after completing this FYUP and/or PG, the career opportunities a young student in the field of Chemical education may have and the detail process of admission along with various job opportunities are also discussed.

2. SCOPES OF HIGHER EDUCATION IN INDIA

The New Education Policy aims to shift higher education from examination to rote learning, focusing on conceptual clarity, critical thinking, problem-solving, innovation, and creativity. In higher-education system in India, there are ample scopes for pursuing undergraduate general education. After completing the secondary education, the next step is in general education is the FYUP which is going to be implemented from the next academic session. After that the students can opt for studying PG course, followed by a research degree and Post Doctoral research as well. The highlights of NEP-2020 in higher education are summarized in [Figure 2]. Nowadays, many reputed universities of various countries are allowed to establish campuses and provide higher education in India. At present, many Indian universities and institutions welcome students from abroad and there are scopes for scholarships for students coming from abroad are also available as well. The NEP aims to transform all higher education institutions into multidisciplinary ones by 2040, with at least one large multidisciplinary institution in every district by 2030. The goal is to boost the gross enrolment ratio in higher education, including vocational education, from 26.3% to 50% by 2035.

2.1. Four-year UG Programme

The credit-based semester system, used in the 3 years degree program, will also be applied to the newly designed FYUP. The credit determines the number of hours (h) of instruction required per week. A credit is equivalent to 1 h of teaching (lectures or tutorials) per week or 2 h of practical class or field works. Students will get credit points followed by grade points. The grade point is a numerical value allocated to each letter grade on a 10-point scale. The important points of FYUP are as follows. FYUP is divided into eight semesters. In the initial three semesters, students will be required to take a common and introductory course of natural sciences, humanities, and social sciences. In the fourth semester, students are required to confirm either major course. The major course is a particular subject and degrees will be awarded in that subject/discipline. Students will have to get the required credits (~50% of the total credit) of the main course in the main subject. On the other hand, a student can get knowledge in a different Minor subject besides majors. Thus, a student pursuing a Chemistry as major course should complete at least 12 credits from a group course in Physics/Mathematics/Statistics or any other subject, the student will get an award of Bachelor of Chemistry (B. Sc.) degree with Minor in any one of Physics/Mathematics/Statistics or else. The FYUP course will include major course, minor courses, courses in other disciplines, language courses, skill courses, etc. After completing the second semester, the students may change the subjects or exit from the programme. Certificate will be issued to the students after completing 1 year (2 semester) of the Programme in selected areas of the study. Students will be given diploma after completion of 2 years (4 semester) studies. After 3 years (6-semester) program of the study, the students will be awarded bachelor's degrees as shown in [Table 1].

Students will also have the option of obtaining FYUP degrees having single major or double major. The student can complete 3 years/4 years of the UG course. A minimum of 50% credit has to be obtained from the main branch i.e. Chemistry in order to get a single major in degree. On the other hand, a student has done 3 years/4 years of UG with minimum of 40% credit from the second main stream will be awarded a bachelor's degree with a double major (Chemistry and another one). On the other hand, a student will be able to get a U.G. degree with honors after completion of 160 credits till the last semester of the FYUP program. However, if a student is interested to become a research specialist and pursue Ph.D. degree in the next stage, then a research project has to be completed in the last semester of the 4-year UG Honors degree under a Supervisor from the department of the College/Institute (UGC, 2023). Then, they will get an honors degree with research expertise.

FYUP will have multiple exit and entry options. If a student leaves the course for any reason, he/she may again rejoin within 3-years of departure and complete the said program within 7 years. In this regard, Academic Bank of Credit (ABC) as per the new National Education

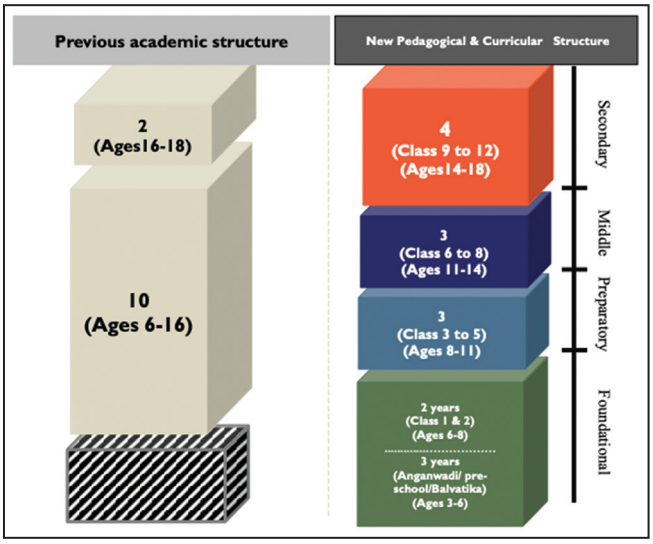

Figure1: School education system as per NEP-2020. Source: National Education Policy 2020.

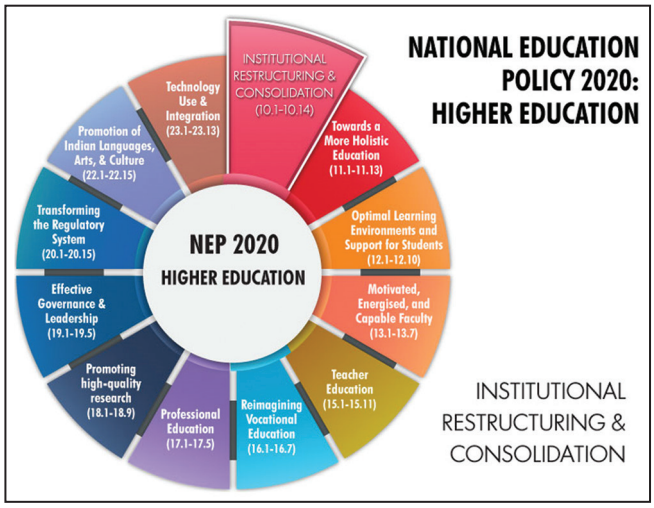

Figure 2: Highlights of NEP-2020 for higher education. Source: Nirma University.

Policy is formed that acts as a virtual/digital storehouse that contains the information of the credits earned by individual students throughout their learning journey. It is envisaged to facilitate the availability of appropriate "credit transfer" system from one program to another through the educational mobility of students having the freedom to study in any institutions, college, or university of India which will easily result in obtaining degrees/diplomas/PG-diplomas etc.

2.2. Challenges of FYUP

To provide FYUP in colleges or Higher Educational Institutions, it requires proper infrastructure, including libraries, journals, computer laboratories, laboratories, and at least two permanent professors for experimental research. The FYUP curriculum has been developed with an aim to recognize and encourage the abilities of each student for their overall development. The focus is on learning, conceptual understanding, ethics, life skills, environmental education, digital solutions, health and wellness, yoga, sports, and fitness to promote rational decision-making and innovation. Above all, the FYUP will allow a multi-faceted and holistic education. The institutions should have all the required facilities for smooth implementation of this program. Chemical education in India has been criticized for poor quality in recent decades due to economic and social developments, despite recent remedial measures aimed at improving the overall quality (Krishnan *et al*., 2019).

Chemical education should incorporate modern teaching methodologies, including software for structure drawing, 3D visualization, molecular modeling, and drug designing, along with e-laboratories, video demonstrations, and virtual laboratory simulations (Bakhshi and Rarh, 2020). These aspects must also be considered. Teachers should be regularly empowered in chemistry education, using technology strategically and participating in professional development programs developed by the National Resource Centres of Chemistry (Bakhshi and Rarh, 2020).

There are some other challenges well. India must have to restructure educational setups. In India, there are two types of educational institutions, namely, Government institutions and private sector institutions providing higher education. There will be a large gap in funding pattern of the two setups that will be reflected in achieving the success of the NEP as well as the FYUP. Central government institutions in India are highly regarded as centers of excellence, demonstrating higher achievement levels compared to state government institutions (Kumar 2021). India aims to transform its education system into one of the best in the world under NEP and the industrial sector has emerged as a new economic power in various fields including information technology and artificial intelligence. The Government has although assured full cooperation in various fields such as upgradation of infrastructure, recruitment of teachers and other aspects. But, in reality, it is very important how much the necessary infrastructure for this new student-centric course FYUP, to be implemented on the basis of NEP in colleges, can be upgraded at the earliest. We hope that this new education system will bring about all-round development of our human resources.

Table 1: The structure and lengths of the degree programme.

Duration	Program	Status
1-year (2-semester)	Certificate	Exit
2-year (4-semester)	Diploma	Exit
3-year (6-semester)	Bachelor degree	Exit
4-year (8-semester)	Bachelor degree with honours OR	Exit
	Bachelor degree with honours and Research	Exit

2.3. PG Degree Programme

After completing a 3 years UG course or 4 years degree with honors/honors degree with research, students will be able to get 2 years Master's/PG degree or 1 year PG degree course. The important points regarding the PG degree are shown in [Table 2]. The students with a 3-year bachelor's degree will be eligible for 2 year (4-semester) PG degree course with 80 credits. While those exit after successful completion of this course of 1-year (2-semesters) and complete 40 credits, it will be awarded Post-Graduate Diploma. On the other hand, students who have completed a 4 year Bachelors Degree program with honors or honors with research degree are eligible for a 1-year (2-semester) PG degree course with 40 credits. However, the concerned University may make some changes in credit related matters.

2.4. Research Degree Programme

There are two types of existing research degree program, the M.Phil. and Ph.D. degree. The important points of these two programs are as shown in Table 3. The students who get PG degrees with at least 55% marks are eligible for admission to 1 year M.Phil. program. However, the M.Phil. Program will not be extended for long. Several universities have already stopped offering the M.Phil. program in accordance with amendments made as per the NEP. After graduating with 4-years and obtaining a PG degree of 1 year (2-semester), the students can enroll for the Ph.D. degree. For that, student must achieve a "B" grade or 55% marks in the 10-point or equivalent scale of the UGC in a 1-year PG degree program. On the other hand, after completing the 3-year UG course, students who have completed a 2-year (4-semester) PG degree course will can pursue Ph.D. degree. For that, grade "B" should be secured with at least 55% marks in the master's degree or 10-point on the UGC or its equivalent scale. Students who have completed 4-year (8-semester) Bachelors (Honors or Honors with Research) can directly pursue the Ph.D. degree. However, the candidate has to secure at least 7.5/10 CGPA in FYUP.

3. ELIGIBILITY TESTS IN HIGHER EDUCATION

Higher education takes students all to acquire expertise by gaining knowledge in a particular subject i.e. Chemistry, as well as intellectual and social development and leading them to careers such as high and skilled jobs. Higher education plays an essential role in helping students realize their career aspirations. The more the students prepare themselves for a variety of competency competitive examinations by pursuing a good higher education, the more likely they are to get a prestigious and profitable job in the next phase and with the acquisition of higher quality degrees. Parents being aware of this will not only encourage students towards medical or engineering careers but also various aspects of higher education. In fact, the level of education students receive directly impacts their chances of securing a job.

Table 2: The structure and lengths of PG programmes.

Program	Eligibility	Duration of PG	Award
Postgraduate	FYUG (Honors/research)	1-year (2-semester)	PG degree
Postgraduate	3-year UG (Major)	2-year (4-semester)	PG degree
Postgraduate	3-year UG	1-year (2-semester)	PG diploma

UG: Undergraduate, PG: Postgraduate.

Many jobs have minimum educational requirements as well as some qualifying tests and one cannot get a job without succeeding in this exam. If the students can study in a special way and pass the different types of qualifying test, they can become more attractive personalities as well as candidates for skilled jobs, which in turn increases the chances of getting a job.

In today's competitive world, it is seen that our students and parents may face a lot of difficulty in getting a job in the later stages of life or have to be satisfied with a simple job due to lack of information about the qualifying tests and their importance and various aspects. Herein, attention of the students and parents has been drawn to some of the interesting competency tests to be faced by the students in the field of higher education and their importance.

3.1. Joint CSIR-UGC National Eligibility Test (NET)

NET is an examination steered to determine the admissibility of a candidate having a P.G. degree for becoming an Assistant Professor which is mandatory qualification of Assistant Professor/Lectureship (LS) and Junior Research Fellowship (JRF) for pursuing Ph.D. in all colleges and universities of India. Apart from this, this examination is open to candidates in their final year of a PG degree or equivalent program. However, such candidates are declared to have passed temporarily and are given the eligibility certificate of Assistant Professor/JRF only after they pass the PG examination. There is no age limit prescribed for appearing in NET/State Eligibility Test (SET) test. But to get the JRF, the candidates should be <28 years of age. Relaxation has been relaxed up to 5 years in case of SC/ST/third gender/disabled persons and 3-year upper age limit in case of female applicants and OBC (NCL) applicants. This test is conducted by the (NTA, 2023).

Joint CSIR-UGC NET test consists of three parts consisting of objective type of multiple choice questions (MCQ). There is no break between each part. The Part-A is the same for all subjects and should be answered to a maximum of 15 questions (2 × 15 = 30 marks) from 20 questions. This section focuses on general skills, focusing on logical reasoning, graphical analysis, analytical and numerical abilities, quantitative comparisons, chain structure, and puzzles. The Part-B consists of subject-related MCQ, in this section a maximum of 35 questions out of 50 are to be answered (the total score is about 70). Each question in Part-B has a score of 2 marks. Part-C consists of higher subject-related proficiency questions, which test candidates' scientific concepts and/or knowledge perceptions of scientific applications of the subject taken. The questions are analytical in nature where a candidate must apply scientific knowledge to answer 20 out of 60 questions in an analytical section. Each question of Part-C has a score of 4 marks (The total score is around 100). Part-A, Part-B and Part-C are tested with a total of 200 marks in all the three parts. Various information related to the test can be accessed on this website https://csirnet.nta.nic.in. The minimum cutoff percentage for the award of JRF/LS/Assistant Professor in different disciplines in the Joint CSIR-UGC test for JRF and eligibility for LS/Assistant Professor held in December-2023 are shown in [Table 4].

3.1.1. Fellowship

JRF selected through CSIR-UGC NET are given a monthly scholarship of Rs. 31,000 for the first 2 years. Apart from this, a surprise grant of Rs. 20,000 is given annually. This fellowship is governed by the terms and conditions of the policy of research of CSIR, UGC. After 2 years as a JRF, if a research subject is registered for a Ph.D. program, the fellowship is upgraded to SRF and the monthly scholarship increases to Rs. 35,000 per month. Ph.D. Fellows are promoted to SRF through interview of candidates with research guides, department heads, and expert committees consisting of external members from the university/institution outside. The candidates having JRF are eligible for LS as well for teaching in colleges, institutions, or universities.

3.2. SET

The SET vary slightly from State to State. This test consists of two papers of MCQ type. There is no break between the exams of the two papers. Paper-I comprises of 50 questions and each question having 2-marks (100 marks). This part assesses the learning/research skills of the candidate. This paper primarily determines a candidate's reasoning ability, comprehension, differing thinking, and general awareness. The Paper-II comprises of 100 questions and each question having 2-marks (200 marks). This is based on the subject chosen. Here, the knowledge of the subject/domain is assessed. The two papers are scheduled for a total of 300 marks test and 180 min. The candidates having SET are eligible for LS for teaching in colleges, institutions, or universities of the concerned state only.

3.3. Graduate Aptitude Test

Graduate Aptitude Test in Engineering (GATE) is a special competitive examination held in India which is conducted every year primarily for admission to PG/M.Tech. and Research programs. Some important posts of central government and public sector offer jobs based on GATE score. The GATE examination is conducted jointly by the National Coordination Board (NCB) constituted by The Indian Institute of Technology (IIT) located at Mumbai, Delhi, Guwahati, Kanpur, Kharagpur, Chennai, Roorkee, as well as the NCB constituted by IISc, Bangalore and the Department of Higher Education, MoE, Govt. of India. Cities where GATE is held are separated into eight zones to facilitate administrative activities. Each of the eight regions is operated by a Zonal Office (IIT or IISc). An organization is designated as The Organizing Institute which handles all aspects related to examination. The host institute for this year's GATE-2024 is the IISC, Bangalore.

This examination is open to candidates currently in their 3rd or 4th year of a 4-year Bachelor's degree or those who have already obtained an UG degree. However, if a candidate is studying in any higher degree study such as the 1st year of PG degree or has already obtained a PG degree is also allowed to appear in the GATE examination. There are no criteria for the age limit prescribed by the managing authority to appear for this examination. The exam consists of 65 questions having 1 mark and 2 marks, with 10 questions focusing on general skills and 55 on chosen subject, accounting for 15% of the total marks. The subjective section comprises 25 questions having 1-mark and 30 questions having 2-marks, that accounts for 85% of total marks. Usually, 1/3rd marks are deducted for wrong MCQ answers (i.e. 0.33

AQ6 **Table 3:** The structure and lengths of PG programs.

Programme	Bachelor degree	PG degree	Duration of research degree	Award
Research degree	4-year UG with Honours and research	Not required	3–5 years	Ph.D. degree
Research degree	4-year UG with Honors	1-year PG	3–5 years	Ph.D. degree
Research degree	3-year UG	2-year PG	3–5 years	Ph.D. degree

UG: Undergraduate, PG: Postgraduate.

Table 4: Minimum cut-off percentage for the award of JRF and LS.

Subject	UR (%)	EWS (%)	OBC (%)	SC (%)	ST (%)	PwD (%)
JRF	59.00	51.50	51.00	39.25	30.50	25.00
LS/assist. professor	53.10	46.35	45.90	35.325	27.45	25.00

JRF: Junior research fellowship, LS: Lectureship.

for wrong answers to 1-mark questions and 0.66 will be deducted for wrong anwers to 2-mark questions) but there is no negative score for MSQ and NAT. The GATE exam aspirants are tested in a smart way. A candidate's GATE score reflects the relative performance level of the candidate. More information about the GATE-2023 test can be found in https://gate.iitk.ac.in. The cutoff marks for the qualified candidates are determined by various factors including- number of applicants who registered for the exam, number of applicants who appeared in the examination, the difficulty level of the exam and the number of seats available in concern institutions. The GATE- Chemistry cutoff marks released by concerned IIT for the last 3 years is shown in [Table 5].

Table 5: GATE-chemistry cutoff marks.

Subject	GEN	OBC-NCL	SC/ST/PwD
GATE-chemistry 2023	32.5	29.2	21.6
GATE-chemistry 2022	30.4	27.4	20.2
GATE-chemistry 2021	36.2	35.5	24.1

GATE: Graduate aptitude test in engineering.

3.3.1. Fellowship

Indian Institutes of Higher Education in various government and other institutions supported by government and other agencies offer PG programs such as M.Tech. and Ph.D. programs in Chemical Science. The Ministry of Human Resource Development and other government agencies offer financial assistance (fellowship) to GATE passed candidates for admission into M.Tech. courses. The monthly fellowship for students is typically Rs. 12,400 and is typically awarded for a period of 22 months. On the other hand, he relevant branch provides a fellowship of Rs. 31,000 pm for the first 2 years and Rs. 35,000 pm for the 3rd to 5th year for the direct doctoral program. It is one of the biggest and highest quality competitive examinations in India. The GATE test is recognized by institutions outside India, including Nanyang Technological University in Singapore.

3.3.2. Job opportunities

GATE scores are utilized for recruitment to Group A posts in the Central Government such as Senior Field Officer and Senior Research Officer.

The advertizements for such posts are published in national newspapers and Rozgar Samachar papers. Some other organizations may also use GATE-scores (IITK, 2022). India's public sector undertakings face recruitment challenges due to low selection rate, with over 100,000 students appearing for <1,000 jobs. GATE marks are now used for recruitment to a variety of posts as well as graduate engineers at the entrance level of PSUs. Some of the notable PSUs are Oil and Natural Gas Corporation, Indian Oil Corporation Limited, Gas Authority of India Limited, Coal India Limited, National Thermal Power Corporation (NTPC), Bharat Heavy Electricals Limited (BHEL), Nuclear Power Corporation of India Limited, Centre for Railway Information Systems, Electronics Corporation of India Limited, Engineers India Limited, National Aluminium Company Limited, Power System Operations Corporation Limited, Rashtriya Ispat Nigam Limited, etc. PSUs have chosen GATE-score as the primary shortlisting condition, following successful testing by IOC, followed by NTPC, BHEL, Bharat Electronics, and Power Grid Corporation of India. Companies typically release employment notifications immediately after the GATE notification.

3.4. Fellowships for Research and Development

Ministry of Science and Technology (DST/DBT/CSIR [DSIR]/SERB) provides various fellowships and funds for research and development in higher education in India. These include: Extra Mural Research Funding (Individual Centric), Scheme for funding High Risk -High Reward Research, Empowerment and Equity Opportunities for Excellence in Science, Start-Up Research Grant (Young Scientists), J. C. Bose National Fellowship, Ramanujan Fellowship, National Post Doctoral Fellowship, Early Career Research Award, SERB Overseas Postdoctoral Fellowship, CSIR Young Scientists Awards, Scheme for Young Scientists and Technologist, IYBA Innovative Young Biotechnologist Award, Sponsored Research (RESPOND), Research Programmes and Projects - Ministry of Earth Sciences, Indo-U.S. Fellowship for Women in STEMM, Fulbright-Kalam Climate Fellowship etc.

4. CONCLUSION

With the implementation of the student centric National Education Policy, India is transforming to a direction of providing better Chemical Education in the form of FYUP and follow-up research degrees. In the end, we appeal to all the students to grab this opportunity of NEP-2020 and the FYUP followed by subsequent levels of higher education to gather knowledge for better career opportunities and become successful.

In our society, it is seen that students have traditionally had to struggle to find a job in the next level after obtaining higher education degrees. But if they can prepare themselves for this kind of qualifying test in advance then we think our students of will definitely be able to show good results in various examinations. It is to be noted that if a student can succeed in these qualifying tests, you can study courses like M.Tech./Ph.D. in the next stage of higher education by getting attractive fellowships. The amount of fellowship offered in this field is much higher than that of a traditional job. Therefore, students should prepare for these exams right from the initial stage. For this, a plan has to be made to prepare yourself as per the syllabus of the respective examinations. The content to be read has to be strategized to prepare study material according to the time available. According to one's own knowledge, the content has to be read in a hurry by giving priority to them. The previous exam question papers available on the website of the respective qualifying examination should be downloaded and printed and practiced. To keep every content in long-term memory a student has to keep it constantly reading as well as discussing it. Above all one has to prepare with the help of an intelligent plan. Sometimes, we succeed when we try to succeed and sometimes, we may fail, but most of the time how much success we have achieved in our lives depends on our preparation and our confidence.

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6. CONFLICTS OF INTEREST

The author declares no conflicts of interest.

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****Bibliographical Sketch***

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