Changing Face of Science Education in India During the COVID-19 Pandemic

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Abstract

COVID-19 pandemic has led educational institutions to be shut down to contain the infection. Still, it was carried out online, which resulted in the students' isolation from physical interaction in contrast to the exploratory nature of Science. As a result, it compelled researchers to investigate the nature of science education during COVID-19. This paper critically analyses the nature of science education in Indian classrooms in a complete virtual mode. The exploratory method was adopted where teachers, students, and parents were interviewed through zoom meetings, and for further information, semi-structured questionnaires in the form of Google forms were shared. The study has been conducted from August to October 2020. The findings reveal that online mode was not favourable for many learners, due to lack of resources and facilities. Responses confirm that it was inadequate to facilitate science teaching and learning in a complete virtual mode as it limits the basic premise of nature of science, i.e., exploration. Students weren't able to perform experiments at home and teachers were not techno-savvy. However, they still managed to teach science at the elementary level, subsequently, a daunting task at secondary and senior secondary level.

The COVID-19 pandemic has tremendously affected the entire world. It has changed the global perspective towards the value of life. It has been observed that the geopolitical aspects, like global economy, social life, environment, and health in terms of physical and

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mental health, have been affected severely. Education has also not been untouched by these circumstances, especially the developing countries, where access to education is not feasible in a formal setup. Governments around the world have temporarily closed educational institutions to contain the spread of pandemic.

UNESCO's report (UNESCO, 2020, *Global Monitoring on School Closure*) revealed that 1,198,969,357 learners were affected among 68.5 per cent of the total enrolled. However, the number of affected learners has decreased, but a huge fall in the number of enrolled students due to COVID-19 has also been noted. The learners are still struggling with long academic breaks. In India, most of the schools remained shut till now (2021). The pandemic has squandered the education system, and still, it is growing rapidly.

The present study laid emphasis on teaching and learning of science education in India up to senior secondary level and the major purpose is to understand how it is affected due to COVID-19 pandemic. It has changed most of the curricular practices such as synchronised and asynchronised pedagogical interventions related to the transaction of course content in virtual classroom setting, 30 per cent deduction of syllabus from CBSE, virtual assessment and e-evaluation strategies are used by most of the secondary schools in various states. It is observed that education is digitalised as the teacher and the students are meeting virtually for the process of learning in developing countries too.

The issue arises here, whether it is affordable for the Indian Students. The reasons for the reconsideration of access to digital education are— First, in India, approximately 6.8 per cent of people are below the poverty line, i.e., less than ₹27000 per annum as family income. Second, India is the second largest populated country in the world. It is hard to imagine, a family including two-three children with less than ₹27000 per annum, can support online mode of education, which demands smartphones, strong internet connection, and electricity. Also in India, remote and inaccessible villages have always proved to be a major challenge in the country's electrification drive (BBC News, 2018).

In addition, data shows that only 54 per cent of the Indian population have an internet facility and that too, it is limited to the urban population with men using the internet roughly twice as requently as women, it is (Hindustan Times, 2020). Consequently, many children are struggling to access education during COVID-19 pandemic, and that too specifically in science education. However, the digital divide in terms of equity and access to online mode of education becomes a prominent query for researchers:

- Why are inequalities occurring in India in terms of access to electricity, internet and devices?
- What are the issues of 'affordability and accessibility' in rural India in terms of education?

The accessibility issues pertaining to science education lie both on the physical and content level. These issues are more prevalent in the realm of science education as the existing discourse concludes on disadvantaged groups (for instance girls, learners with disabilities, those who belong to remote/rural/tribal areas) in science. In addition, the position paper of 'Teaching of Science', NCERT (2006) also acknowledges 'equity' as a significant issue in science education. Therefore, this study presents a critical perspective on virtual education with reference to 'school science education'.

Literature Review

A study by KMPG in India and Google (KMPG in India and Google, 2016), reveals that India witnessed a significant increase in the total internet users population by 31 per cent till 2016, where maximum use of online learning mode has been adopted by primary and secondary school learners and expected to grow from 409 million internet users to approximately 735 million by 2021. Besides, studies have shown some negative impacts of online mode of education such as reduced employment opportunities, unpreparedness to online platforms for students and teachers, loss of nutrition due to school closure (provision of mid-day meal), lack of resources hindering access to education, less parental support (for first-generation learners 2020;) (Jena, 2020 and Shin, 2020). This school closure not only causes serious damage of quality education for children but also increases the issues in society such as child labour, child marriage, exploitation, early pregnancy and loss of nutrition (absence of mid-day meal) (UN, 2020). It is recommended that distribution of digital devices and support access to online platforms expand the reach of learners through television programmes, and encouragement of learning outside the prescribed syllabus must be there (Shin, 2020). As India has been seen as a country developing online mode of education, blended or flipped education can help to achieve an optimal balance between e-education and traditional education (Say and Ildirim, 2020; Palvia et al., 2018). Studies suggest that science education should be based on a constructivist approach but how the practical part would be handled in such a situation was still doubtful (Deshmukh et al., 2012); in this situation, the role of a parent is crucial when a child learns science at home. Parents' own affective experiences, organisation of the experiments and finding time to do experiments are important factors to consider (Vartiainen and Aksela, 2019). Therefore, it is emphasised

that the interdisciplinary approach be adopted to teach science during the COVID-19 pandemic through philosophical, sociological, and historical dimensions of science (Reiss, 2020). However, how students, teachers, and the administration will adapt to complete online mode of education and how efficient it would be in reference to science education, is still questionable.

Initiatives taken by the Government of India

To facilitate online mode of education, the Government of India has taken some initiatives as discussed below (Fig. 1).

Along with digital platforms, the Government of India has also issued PRAGYATA guidelines for online mode of education for students, teachers and parents.

Resources	Description
SHAGUN	An online junction under which the Department of School Education in the Government of India have launched several e-learning platforms
National Repository of Open Educational Resources	Facilitates e-books, e-libraries, online discussion, e-courses, webinars, etc., it is available with 5923 documents, 141 interactives, 2777 audios, 2583 images and 6391 videos
DIKSHA	Equips teachers and students from Classes I to XII into the world of e-learning
SWAYAM and SWAYAM Prabha	A programme initiated for students from Classes IX to XII and those pursuing undergraduate or postgraduate degrees, all can access learning materials here and Swayam Prabha is a collection of 32 DTH channels which run 24×7 for the multiplication sign
PMeVIDYA	A multi-model digital online learning education platform
e-Pathshala	A web portal where students can access learning material from Classes I to XII
National Academic Depository (NAD)	24×7 online storage of all academic awards, run by UGC
Virtual Labs	Another key initiative of MHRD and the Government of India under the mentorship of NMEICT
National Digital Library of India	To provide content to not just school students but also students pursuing higher education and Ph.D. level education

Fig. 1: Initiatives taken by the Government of India to facilitate Online Education

Research questions

1. How do online platforms influence the nature of science education?
2. How do students and teachers adapt to a complete online mode of learning and teaching of science and what are the distinct science pedagogical strategies adopted by teachers?
3. How school administration is intervening and facilitating online Science education accessible to all the students?
4. How does the perception of parents towards online teaching influence students' learning?

Methodology

The nature of this research is qualitative. The objective is to understand the nature of science and to know the challenges and issues that emerged in science teaching-learning in online mode of education. Further, triangulation was done to understand the teachers', students', and parents' perceptions about online science education. It also analyses the input of stakeholders on facilitation of resources during pandemic.

A purposive sampling criterion is opted and the sample of the study is— students at secondary and senior secondary level (who opted science stream), TGT and PGT Teachers of science stream, and Parents (of selected students) of the Government Schools.

The semi-structured questionnaires were distributed among parents, teachers, and students through Google forms. A focus group discussion of teachers of secondary and senior secondary schools was conducted. The responses were analysed through thematic analysis under different themes. The data was collected from the month of August to October (2020).

Data Analysis

Perception on Online Mode of Learning

This section includes perception of students, teachers and parents towards online mode of education. Data reveal that students spend a minimum of 2 hours to maximum 4 hours on screen, which is similar to

Sample	Tools	
	Questionnaire	***Focus Group Discussion***
Parents	7	–
Teachers	8 (5-TGT*, 3-PGT**)	3 (1-TGT*, 2-PGT**)
Students	62 (Class IX—12, Class X—48, Class XI—2)	–

** Trained Graduate Teachers ** Post Graduate Teachers*

Fig. 2: Sample of the study

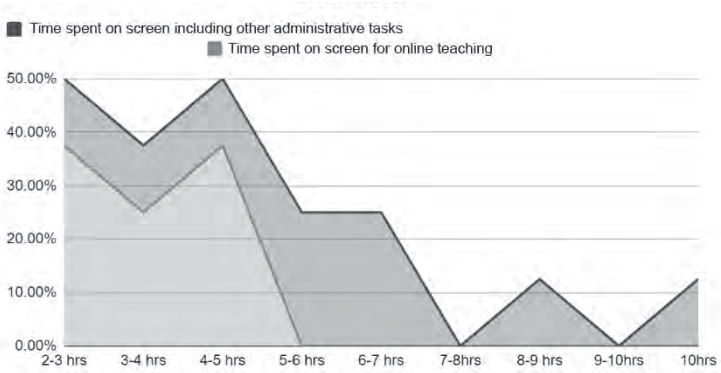

Fig. 3: Time Spent by Teachers on Screen in Online Mode of Education

the guidelines of PRAGYATA (2020) as proposed by the HRD ministry of Government of India. Their science classes are scheduled for a minimum 30 minutes to maximum 1 hour. Teachers who responded were TGT and PGT; therefore, their responses differed with respect to their experiences and academic achievement.

It was found that teachers spend 3 to 5 hours in online classes per day, and 10 hours with other administrative work per week (Fig. 3).

Teachers' perception on teaching science in online mode reveals that most of the teachers consider online mode as an opportunity, whereas others see it as an imposed decision which is beneficial only to those who have access to resources. Teachers don't consider online mode efficient to develop scientific attitudes. Their reactions are given hereby.

Teacher 1: "I found that being practical using their nearby things makes it easier to teach about the topic and for them to understand, but without face-to-face interaction,

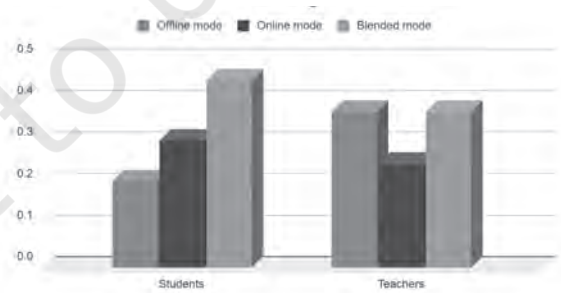

Fig. 4: Perception of students and teachers on different modes of learning

it is difficult for them to understand completely."

Teacher 7: "It is not favorable for economically weaker students."

Figure 4 reveals that around 45.2 per cent of students agreed on a blended mode of learning. On the other hand, 30.6 per cent students favoured online mode and 21 per cent students are in favour of offline mode of learning. Among them, 37.5 per cent teachers were in favour of offline mode, whereas 37.5 per cent favoured blended mode and 25 per cent agreed on online mode. Teachers faced challenges during teaching online, for instance, unavailability of resources, lack of physical presence for teaching science, lack of teaching environment at home, a completely online mode of teaching and teachers miss the physical presence of the students. Few teachers responded they didn't get any support from the school or administration, whereas some schools are providing adequate support to their teachers for the facilitation of online mode of education by providing resources (including internet, laptop, learning material, etc.), organising workshops with timely motivation, and providing suggestions in reference to online teaching.

Due to a change in the mode of learning, 50 per cent of parents believed that the child is active, whereas 50 per cent said that they are becoming passive learners. Interestingly, most parents agreed that during pandemic, online mode is favourable for continuing education, as well as for health and safety, but some of them also argued that it caused headache, eyesight weakness, ear related disease. According to parents, their children spend at least four hours per day in a virtual classroom. Parents were inquired if they have observed their children's online classes, some responses are given hereby.

"Online classes are good because it provides new normality in education now students can achieve knowledge beyond syllabus. This approach is accessible anywhere any time by any person so it creates a sense of endless learning where the sky is limitless. Online mode of education is the education which facilitates learners for self-learning approach".

"Online mode of education is helpful but not appropriate for interaction between teachers and students."

It is noted that online classes were happening in the presence of parents and hence, online classes had a surveillance of parents. Moreover, a majority of teachers do feel the pressure of being observed during classes.

Accessing Resources

Managing resources and learning material was the major challenge in online mode of education, as around three-fourth of students in India did not have access to the internet at home (*The Hindu*, 2020). Likewise, the data shows that most of the students

access online mode of education through smartphones. Students mentioned various mediums such as textbooks, YouTube, SWAYAM and material given by teachers, among which textbooks and YouTube were the major means of accessing learning material. As parents have to manage the resources, hence, in many homes, children are able to attend classes from a single smartphone because of different schedules. However, many parents had to buy smartphones, tablets and laptops while others face challenges like space, unavailability of mobile phones, laptop, printer, etc., in relation to online classes.

Teaching and Learning Science Through Online Mode

Learning science without exploring the physical world is an enormous challenge. However, considering the pandemic, online mode is the only option. While conversing with teachers, teaching science to Classes IX–XII, the common ideas are—teachers were not techno-savvy, never have they ever used online platforms to this extent in their offline classes. However, with time they learned things and now have become used to it. Initially, they faced many challenges such as lack of resources (laptop, mobile phone, printer, Wi-Fi, etc.), teaching ethos, practice, etc. They learned things from their children, colleagues and school administration. Besides, the major issue was internet accessibility. Teachers adapted pedagogies like inquiry method, activity method, lecture method, experimentation, demonstration, and the resources they have used were mainly videos, virtual laboratory, textbooks, online mode of education portal SWAYAM, online learning material, etc. Among them, YouTube videos and textbooks were the frequently used mediums for transaction. Notably, teachers introduce scientific concepts via inquiry method or by informing them earlier in the class or by relating it with the surroundings. And when it comes to the experimental portion; teachers tend to send the link of related videos to the students. Teachers mentioned that they engage students in online classes by discussing their problems and taking their names while teaching.

It is necessary to understand how students cope with the issues related to online mode of learning; the data revealed that around 80 per cent students believed that online mode is not as good as offline mode. When students were asked about their opinions on learning science via online mode, some responses are—

- Student 1: "Many of my scientific concepts are still not clear. Learning online is a bit complicated for me. For a proper understanding, I need someone who is teaching me face-to-face. Online classes are helpful but offline classes are better."
- Student 29: "Being a class 11 science student, I feel that the reduction in syllabus and

commencing the new session with online mode of education, I felt a little disappointed. There was a lot of curiosity and excitement I possessed earlier for learning science, but in online teaching the fun just got away, it feels like a formality now. My science education has changed drastically according to me, it has become a matter of facts and not understanding. Yet there are plus points like the extra efforts made by teachers to ensure that we grasp things well."

The above responses indicate that students are struggling with issues while learning science at home. Experiments are an essential part of learning science and enable students to develop process skills. However, few reports claim that students with science streams are using virtual labs without compromising the quality of education (*India Today*, 2020), whereas the data shows that 53.2 per cent students were not able to perform experiments at home even through virtual labs, and those who were able to perform, found it challenging to manage material. Some responses in support are—

- Student 3: "At school, there are teachers who take care of ourselves as well as they tell us how to do experiments with precautions. It feels safe with teachers because they tell us our mistakes too and they have more knowledge than us."
- Student 4: "Laboratory has all the things which are required but it is difficult to arrange the things at home."

Another reason is that parents consider scientific experiments as 'dangerous' and hence do not allow their child to perform it at home, because their education is not in the science background. According to them—

"Science can be taught online but when it comes to experimental explanation there would be difficulty

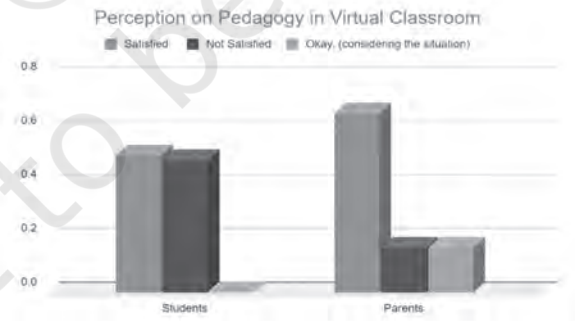

Fig. 5: Parents' and Students' perception on Pedagogy in Virtual Classroom

in understanding, lack of space, and lack of a learning environment at home is not supportive to understand scientific concepts."

So, students were taught through various means. When parents and students were asked if they are satisfied with the pedagogy practiced in their child's online classes, the results show that most of them were satisfied while the remaining were okay, considering the current scenario.

Responses show that 50.8 per cent of students were satisfied with the teachers' effort whereas 49.2 per cent of students were not satisfied, because in some classes, teachers teach them through PPT or video which makes it boring as they desire some interaction with their teachers during the classes as it happens frequently in an online classroom that they are instructed to mute their mic and camera and the classroom lacks any interaction. Ironically, parents consider it most convenient contemplating the current scenario and 66 per cent parents were satisfied with teachers' efforts for making education successful even in the era of COVID-19. Some responses are—

- "No. Showing PowerPoint presentations and explaining them is not enough in order to get a proper understanding of the concept."
- "I am satisfied because they are doing all that they could. Each of us needs to understand that it's impossible to create an engaging environment in online mode, so we just need to emotionally connect and try our best in the class."

Figure 6 affirms that 58 per cent of students were accessing science education through private tuitions, among which 62 per cent students are taking it through online mode. 61 per cent of students responded that there are remedial classes from their school teachers, but it is limited to

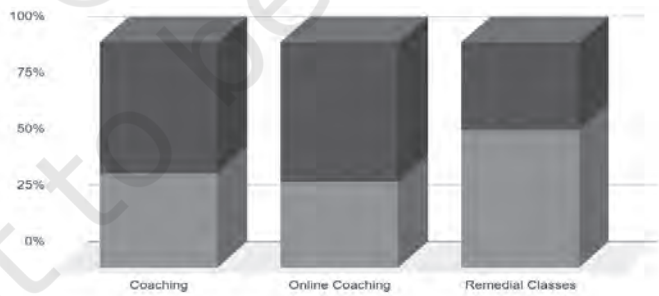

Fig. 6: Students Accessing Alternatives for Learning

the students, who score less. Some students understand the pandemic situation as a temporary phase, so their expectation from teachers was not much regarding engaging the classroom or understanding concepts. One obvious reason for their dissatisfaction was that learners were habituated to face-to-face teaching, thus, due to sudden shift they were struggling to adapt to the new approach.

Parents admitted playing an important role in their child's learning, especially if it is from home. In response to how they support their children's learning, they answered—by providing resources and assistance during class, observing classroom, solving their doubts while studying, helping them in activities such as drawing, coding preparation for Olympiad, etc. Due to change in the mode of learning, students' learning style has also been affected; the researchers got mixed responses from parents, such as—

- "They have started using technology more than referring to books."
- "Before pandemic children went to school, it helped them in physical and mental activities while in pandemic only mental activities are involved."
- "I think now she is more aware and searches for some new AppSource for learning on daily basis so her capacity for self-searching and self-learning is raised."

Online Assessment

The data reveals that maximum teachers assess their students through MCQ tests, weekly assignments, and on the basis of their activeness or engagement in virtual classroom, online quiz, etc. They mentioned various means to solve students' queries, for instance, addressing queries in a virtual class, through WhatsApp, by organising remedial classes, taking doubt sessions, etc.

Suggestions

Students' suggestions indicate that they require extra efforts from teachers. Therefore, teachers need to be sensitive to the present scenario and they should adapt their pedagogical strategies according to the mode.

- "Teachers should be more interactive with students."
- "Being a senior secondary student, I think, teachers in our system are very capable of good teaching, I would just want them to be a little more understanding and less insecure, because we as students tend to read that in their voice. We understand and we too sometimes deserve a good lesson, but being angry and agitated throughout the week is not a good idea for anyone. If this would be read by teachers actually, I would like to thank them for their efforts and promise my obedience during online classes. With respect."

Some parents considered the attitude of teachers towards students

as important as their pedagogical approach. Thus, they suggested that teachers should be more empathetic to the students in such times. They verbalised:

- "Teachers need to have good communication skills and empathy towards students".
- "The only suggestion is to make the students interact with their surrounding things while they are learning so they can enjoy and learn at the same time."

It is imperative to know that parents are conscious about their children's education.

Findings

1. Due to a sudden shift in education from traditional classroom teaching to online mode of education, students including teachers have faced difficulty while managing resources such as internet, laptop, smart phone, electricity, etc.
2. Teachers and students weren't techno-savvy.
3. Teachers believed that it is difficult to teach science through a complete online mode because of its exploratory nature.
4. Students were not able to perform experiments at home especially at secondary and senior secondary level, due to lack of necessary material and apparatus.
5. YouTube videos and textbooks were the popular source of content.
6. Teachers also struggled as they had to teach while doing other administrative works through online platform from home in a non-conducive environment.
7. The responsibility of parents increased for their children's education at home during pandemic and they had to continuously indulge there. Therefore, parents with low educational qualification were helpless to support online education.

Discussion

Even in pandemic situation, education was imparted via online mode, but it was not successful to fulfill the objectives of science education, i.e., exploration, investigation, experimentation, developing process skills, etc. It has also led to a digital divide among learners; knowledge was limited to those who can afford e-resources even after many initiatives were taken by the Government of India. Accessing education in tribal or remote areas was always a challenge in India and due to pandemic; they were not able to avail many educational opportunities (*The Hindu*, 2020). Except the national capital, Delhi (with 55 per cent households having internet facility), there are ten other states with less than 20 per cent internet penetration including States with software hubs such as Karnataka and Tamil Nadu. On the other hand, those who were attending online classes were

struggling with many issues, mostly while managing resources, and for girls, it was difficult to study from home (Center for Global Development, 2020). Despite the lack of resources, some had issues with the approach too, like the technical issues (e.g., unstable internet connection) mostly ending up in an incomprehensible transaction. Further, students complained about teachers' insensitivity and less interactivity.

The teachers were struggling with their own personal and professional life issues, for instance, spending 10 hours on screen including administrative work and working from home was not an easy task for them, not receiving any support from their school administration and involving themselves in their own children's learning process too, led to burnout. It is concluded that teaching at elementary level was manageable for them including both theoretical and experimental componented whereas teaching at secondary or senior secondary level became challenging because: (i) concepts become more abstract and technical, (ii) the objective of science education shifted to practical aspect with an emphasis on experiments or technology and problem solving, and (iii) acquiring process skills. Thus, it requires the collaboration of peers, teachers, and a conducive learning environment to comprehend scientific concepts.

Besides teaching, assessment is considered as another defying task for teachers. Since education continued through virtual classrooms, they were unaware about the effectiveness of their pedagogy and achievement of teaching. Moreover, teachers felt that they were losing control over their own classroom and how will they ensure justice, while assessing the students was still a question.

In the pandemic, science is considered as a way to overcome the crisis. Still, its practices were limited to explaining scientific concepts rather than conducting scientific inquiry; the Indian science classrooms were limited to learning definitions. Some teachers argued that science is only possible in a physical environment where students can see each other. On the flip side, parents view online mode as an opportunity. According to them, the horizon of their child's learning has been increased and now, they can access various domains of knowledge other than the prescribed syllabus.

Conclusion

On the basis of the above discussion, the researchers concluded that virtual science classrooms lack experiential learning, where learners are bound to learn science through virtual mode rather than the real world. The epistemic understanding of science needs empirical investigation where the involvement of sense plays a vital role to develop schemes. Due to lack of physical interaction, peer interaction and teacher facilitation have been compromised. As a result, the epistemic understanding of

learners suffers in a virtual science classroom. On the other hand, teachers were unable to get feedback of their pedagogical strategies, rather than interacting with students, they were seeking different means such as PPTs, YouTube, and textbooks and ignored the dialogical space. Apart from that, teachers were unaware of the various learning platforms and virtual labs, for instance, virtual labs by Government of India, nextsciencelab.in, edutechindia.com, etc. Hence, it can be concluded that virtual classrooms were inefficient to ensure a democratic classroom. Instead of using digitalisation as an opportunity, both teachers and students had struggled only due to lack of ICT skills.

Another aspect is the sudden shift to complete digital education teaches our existing education system that the government and other stakeholders should be prepared for any crisis. Also, digital education can be considered as an alternative measure for various other causes of school closure, for instance, pollution, natural disasters, social movements, etc. The government should ensure to be prepared well in advance with the requirements for the facilitation of digital education such as training and programmes, and timely arrange workshops to acquaint the teachers with ICT skills.

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