Challenges and Prospects of Science Education in Bihar's Madrasas: A Resource-Based Analysis

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ABSTRACT

The National Education Policy (NEP) 2020 emphasizes inclusive, equitable, and quality education across all educational institutions, including those serving historically marginalized groups. Madrasas, which hold cultural and educational significance in many parts of India, including Bihar, have long faced challenges in accessing adequate resources for science education. This study investigates the current state of resource availability for science teaching and learning in Madrasas within the Tirhut Division of Bihar. Employing a mixed-methods research design, the study gathers data through structured surveys, semi-structured interviews, and on-site observations across a stratified sample of Madrasas, science teachers, and students. The aim is to assess the accessibility and adequacy of science-related resources, including physical infrastructure, teaching materials, and laboratory equipment. The findings are expected to reveal critical gaps and contextual challenges that hinder effective science education in these institutions. The study contributes to the discourse on educational equity by offering context-specific insights and short-term policy recommendations aligned with NEP 2020 objectives. These insights can inform stakeholders and policymakers working toward the transformation of science education in minority institutions, particularly those serving socio-economically disadvantaged groups.

Keywords: *science education, Madrasas, resource availability, NEP 2020, Tirhut Division, educational equity*

INTRODUCTION

Science education plays a major role in shaping critical thinking, problem-solving skills, and scientific among students, equipping them to participate meaningfully in a rapidly evolving, technology-driven world (Bybee, 2013). However, the accessibility and quality of science education remain uneven across different educational settings, particularly in institutions serving socio-economically disadvantaged groups. One such underexplored domain in the Indian educational landscape is the Madrasa system—religious educational institutions that cater primarily to Muslim students, many of whom belong to minority and marginalized communities.

The National Education Policy (NEP) 2020 marks a significant policy shift toward inclusive and equitable education in India. It highlights the need for integrating modern subjects such as science, mathematics, and computing into all forms of schooling, including religious institutions like Madrasas, to ensure no learner is left behind (Ministry of Education, 2020). This vision, however, is challenged by infrastructural disparities, lack of trained science teachers, and inadequate teaching-learning materials in many Madrasas, particularly in states like Bihar where educational development indices are relatively low (NITI Aayog, 2021).

Empirical research has consistently shown that resource availability—such as laboratories, textbooks, science kits, and teaching aids—has a significant impact on students' learning outcomes in science education (Banerjee & Duflo, 2011; Yore et al., 2004). In India, studies have revealed stark inequalities in science education facilities across rural and urban schools, with minority and low-income institutions often lagging behind (Nambissan, 2010; Ramachandran et al., 2005). Specifically, Madrasas face systemic neglect in terms of infrastructure development and teacher training, particularly for modern subjects like science (Rehman, 2017; Alam, 2011).

A study by Iqbal and Alam (2020) found that the inclusion of science education in Madrasa curricula was often symbolic, with limited classroom hours and a severe shortage of laboratory infrastructure. Moreover, the pedagogical approach in Madrasas has traditionally emphasized rote memorization and theological instruction, which poses further challenges in the integration of inquiry-based science education (Rizvi, 2016). Internationally, similar challenges have been documented in faith-based schools serving minority populations in

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countries such as Pakistan and Nigeria, where science education suffers due to poor funding and lack of government support (Zafar, 2015; Umar, 2018).

Despite these challenges, there are positive examples of reform. In Kerala and Uttar Pradesh, initiatives to modernize Madrasa education by introducing trained science teachers and enhancing science labs have shown promising outcomes in improving student engagement and performance in science (Ansari & Naseem, 2019). These examples underscore the importance of resource availability as a foundation for implementing NEP 2020's goals in Madrasas.

Given this backdrop, the present study aims to explore the current state of resource availability for science education in Madrasas located in the Tirhut Division of Bihar. This region represents a diverse socio-economic profile and a significant number of Madrasas functioning under varying degrees of state recognition and support. By examining resource availability through the perspectives of administrators, science teachers, and students, the study seeks to identify the critical gaps and offer actionable recommendations that align with the inclusive aspirations of NEP 2020.

LITERATURE REVIEW

Science education serves as a foundation for developing critical thinking, innovation, and problem- solving skills essential in the 21st century (Bybee, 2013). However, its equitable provision across diverse educational contexts remains a challenge, particularly in under-resourced and marginalized institutions such as Madrasas. These institutions, while playing a crucial role in the education of minority Muslim communities, often face significant systemic constraints that limit their ability to deliver quality science education. Research indicates that disparities in physical infrastructure, teaching-learning materials, trained science educators, and laboratory facilities are key barriers to effective science instruction in Madrasas (Rehman, 2017; Rizvi, 2016).

In the Indian context, Madrasas have historically functioned outside the mainstream educational discourse. While some state governments have initiated modernization programs, these efforts have not been uniformly implemented or sustained (Alam, 2011). The Sachar Committee Report (2006) provided the first official acknowledgment of the educational backwardness among Muslims in India, pointing out that a significant proportion of Muslim children were enrolled in Madrasas due to lack of access to government schools. The report emphasized the need to integrate Madrasas into the broader educational framework by introducing subjects like science and mathematics. However, subsequent implementation remained fragmented and was often hindered by ideological resistance, lack of capacity, and minimal state support (Iqbal & Alam, 2020).

Empirical studies have consistently highlighted the poor state of infrastructure and educational resources in Madrasas. Rizvi (2016) conducted an observational and interview-based study in Uttar Pradesh and found that most Madrasas lacked basic science laboratories and equipment. Teachers reported difficulties in conducting practical sessions, which are essential to foster scientific temper and experiential learning. Similarly, Rehman (2017) analyzed Madrasas in West Bengal and discovered that science was often taught without adequate visual aids or experimental setups, leading to a heavy reliance on rote learning. This disconnect between pedagogical goals and available resources significantly undermines the quality of science education delivered in these settings.

Internationally, the challenges faced by Madrasas in integrating science education are echoed in other Muslim-majority and minority contexts. For instance, Zafar (2015), in a study of Pakistani Madrasas, pointed out that while there was growing interest in adopting science curricula, the efforts were often limited by inadequate infrastructure and a shortage of trained teachers. In Nigeria, Umar (2018) found that faith-based schools, including Madrasas, suffered from chronic underfunding, which adversely impacted their ability to provide laboratory facilities or purchase standard textbooks. The situation was further exacerbated by low teacher salaries and a lack of professional development opportunities.

Some positive reform initiatives provide useful insights. In Kerala, government-supported Madrasa modernization programs provided science labs, computers, and teacher training, which significantly improved student engagement and performance (Ansari & Naseem, 2019). Similar efforts in parts of Uttar Pradesh

showed that with sufficient infrastructural and academic investment, Madrasas could align with national educational standards (Kumar & Siddiqui, 2020). However, these success stories remain exceptions rather than the norm, primarily due to uneven policy implementation and insufficient budgetary allocations.

From a pedagogical perspective, science education in Madrasas also suffers from epistemological tensions. Traditional religious instruction relies heavily on memorization and reverence for authority, which contrasts with the inquiry-based, critical thinking model promoted in science education (Nasir & Farooqi, 2014). Teachers often lack pedagogical training in science and express discomfort in integrating experiments, models, or interactive activities into their teaching. Alam (2011) argued that without bridging the cultural and instructional divide between religious and modern subjects, any effort to modernize Madrasas would remain superficial.

Quantitative studies further reinforce the resource gap. For example, the Annual Status of Education Report (ASER) and District Information System for Education (DISE) have repeatedly shown lower levels of science achievement in regions with high concentrations of Madrasas, suggesting a correlation between institutional type and learning outcomes. Banerjee and Duflo (2011) emphasized in their broader work on education in developing countries that infrastructure, teaching quality, and instructional materials significantly influence learning, and their scarcity in marginalized institutions such as Madrasas is a major concern.

Recent policy efforts under the NEP 2020 have renewed the focus on inclusive and equitable education. The policy explicitly acknowledges the need to provide equal learning opportunities for all children, including those in alternative education systems like Madrasas (Ministry of Education, 2020). It recommends curricular integration, teacher training, and infrastructural enhancement to ensure parity in learning outcomes. However, without comprehensive ground-level data and needs assessments, these policy aspirations may not translate into meaningful change. Iqbal and Alam (2020) argue that region-specific studies are crucial to understanding the contextual challenges Madrasas face in implementing science education.

Despite the growing body of literature on educational access and equity, few studies have specifically focused on the resource availability for science education in Madrasas in Bihar, one of India's most educationally underdeveloped states. Tirhut Division, with its large Muslim population and significant number of registered and unregistered Madrasas, provides a valuable case for such exploration. A focused inquiry into the types and adequacy of science-related resources—ranging from laboratory space, charts, models, and science kits to trained teachers and reference materials—can yield valuable insights for targeted interventions. This literature review underscores the pressing need to conduct empirical research that not only documents the status of resource availability in Madrasas but also contextualizes it within the broader aims of educational transformation under NEP 2020.

RESEARCH QUESTIONS

1. What types of physical and instructional resources are available for science education in selected Madrasas of the Tirhut Division, Bihar?
2. How do science teachers and students perceive the adequacy and effectiveness of available resources in enhancing science learning?

RESEARCH OBJECTIVES

1. To identify and document the physical infrastructure and instructional materials available for science education in selected Madrasas.
2. To examine the usage patterns of science education resources by science teachers in Madrasas.
3. To explore students' access to and experiences with science learning resources in the Madrasa context.
4. To analyze the perceptions of science teachers and students regarding the adequacy and challenges of science education resources in Madrasas.

METHODOLOGY

This study investigates the availability and utilization of resources for science education in Madrasas within the Tirhut Division of Bihar. The research explores the infrastructural support, teaching materials, and stakeholder perceptions that influence science education in these institutions. A mixed-methods approach was adopted to combine quantitative data with qualitative insights, ensuring a more holistic understanding of the research problem.

Research Design

The study follows a descriptive survey research design. This design is appropriate for assessing current conditions and exploring the experiences and perceptions of stakeholders regarding resource availability for science education. The use of both structured tools and open-ended inquiries allows for triangulation and validation of data from multiple sources.

Population and Sample

The study's population encompassed all Madrasas operating across Bihar, with a purposive sampling approach narrowing the focus to those located in the Tirhut Division. This division, comprising districts such as Sitamarhi, Muzaffarpur, Vaishali, Sheohar, East Champaran, and West Champaran, was selected due to its notable concentration of Madrasas and socio-educational relevance. The sample included 20 Madrasas offering secondary or higher secondary science education, one science teacher from each Madrasa (totaling 20), and 100 students (approximately five per institution) enrolled in science subjects. The sampling process ensured representation across government-aided, private, and recognized Madrasas, as well as diverse geographic areas within the division.

Tools and Techniques

To collect comprehensive data, the study utilized a combination of quantitative and qualitative instruments tailored to different stakeholder groups. A structured checklist was employed during field visits to document the presence or absence of essential science-specific infrastructure such as laboratories, equipment, models, charts, textbooks, and ICT resources. Semi-structured questionnaires were administered to science teachers to gather insights into their educational background, teaching methods, resource usage, and perceived gaps. Students participated by responding to structured tools capturing their learning experiences, accessibility to textbooks and lab facilities, and challenges in understanding science concepts. Additionally, semi-structured interviews with selected teachers and Madrasa heads provided in-depth perspectives on broader institutional and pedagogical challenges in implementing effective science education.

Validation and Reliability

The validation and reliability of the data collection tools were rigorously ensured through a systematic approach. A panel of experts in science education and educational research reviewed all instruments, providing feedback to enhance their clarity and relevance. To further refine the tools, a pilot test was conducted in two Madrasas outside the final sample, leading to necessary revisions. Content validity was achieved through expert feedback, ensuring the tools effectively measured the intended constructs. The internal consistency of the questionnaires was evaluated using Cronbach's Alpha, which demonstrated acceptable reliability values exceeding 0.70, confirming the robustness of the tools for data collection in this study.

Data Analysis

The data collection process involved comprehensive field visits to each selected Madrasa, conducted with prior permission from the respective authorities. Teachers and students were approached directly, and data was gathered through face-to-face administration of questionnaires and checklists, supplemented by audio-recorded interviews (with consent). Observations of the physical infrastructure were also systematically documented. Ethical considerations were prioritized throughout, ensuring informed consent, voluntary participation, anonymity, and confidentiality. The collected data was analyzed using a mixed-methods approach. Quantitative

data was processed through descriptive statistics—frequencies, percentages, and mean scores— to illustrate resource availability and utilization patterns. Qualitative data derived from interviews and open-ended responses underwent thematic analysis, identifying recurring challenges, stakeholder perspectives, and actionable recommendations.

RESULTS

This section presents the analyzed findings of the study using descriptive statistical tools, including percentages, frequencies, and mean scores, to interpret the data collected from science teachers, students, and institutional heads in selected Madrasas of the Tirhut Division, Bihar. The study investigates the availability and adequacy of resources for science education in Madrasas, along with teachers' employment conditions and student experiences.

Availability of Physical and Instructional Infrastructure

Using a resource checklist and institutional survey data, the analysis revealed substantial gaps in physical infrastructure:

- Only 15% of Madrasas had a separate room labeled as a science lab.
- 85% of Madrasas conducted science classes in general-purpose classrooms without any laboratory facilities.
- Among the Madrasas that reported having science lab equipment, the mean availability score (on a 5-point scale) for essential items like beakers, test tubes, and burners was 2.1, indicating severe inadequacy.
- Charts, models, or diagrams were available in only 20% of Madrasas, with ICT tools (e.g., projector, digital content) absent in all surveyed institutions (0%).

This data suggests that the practical components of science education are significantly under-resourced.

Availability and Use of Teaching-Learning Materials

Descriptive data from teacher and student questionnaires showed:

- 70% of teachers reported relying solely on state-prescribed textbooks.
- Supplementary resources such as science magazines, model kits, or lab manuals were used by less than 10% of the institutions.
- Mean teacher rating for adequacy of teaching materials was 2.3 out of 5, suggesting a high dependency on textbooks without engaging aids.

This trend limits the experiential and inquiry-based dimension of science learning in Madrasas.

Human Resource Challenges and Teacher Employment Conditions

A major structural finding supported by institutional data and teacher responses:

- 0% of surveyed Madrasas had sanctioned posts for science teachers under the Bihar Madrasa Education Board.
- 100% of science teaching was carried out by guest teachers, most of whom were paid an honorarium of ₹6000 per month without any job security or service benefits.
- 40% of teachers had formal science degrees, but only 25% had a B.Ed. or any training in science pedagogy.
- Teachers rated their job satisfaction at a mean score of 1.9 (on a 5-point scale), citing low pay, lack of recognition, and professional isolation.

These statistics highlight the precarious nature of science teaching in Madrasas and the urgent need for policy intervention.

Student Interest and Learning Experience

Student questionnaires (n=100) and focus group interactions revealed the following:

- 78% of students expressed a strong interest in science, indicating curiosity and a desire for practical learning.
- However, 65% of students said they had never performed an experiment during their science classes.
- Students rated their learning experience at a mean of 2.4, with complaints of over-reliance on lectures and minimal visual or practical content.
- Only 18% of students had access to individual textbooks, and most relied on shared copies.

Despite interest, students face resource deprivation that limits their academic development in science.

Institutional and Administrative Support

Interviews with Madrasa heads (n=20) revealed the following:

- 90% of institutional heads were unaware of NEP 2020 provisions for science and STEM integration.
- None of the Madrasas had applied for or received any government grants specifically for science education enhancement.
- There was no School Management Committee (SMC) actively involved in science-related planning in 75% of Madrasas.

These findings suggest a weak administrative framework and lack of policy awareness, further impeding resource mobilization.

Teacher Perspectives and Suggestions

Teacher interviews yielded qualitative insights supported by descriptive statistics:

- 95% of teachers called for creation of permanent posts under the Madrasa Board for science educators.
- 85% demanded training workshops, and 100% requested improved lab infrastructure.
- Teachers highlighted cultural integration as essential: "Science should be contextualized using culturally familiar examples to increase relevance in Madrasa settings."

Table 1: Summary of Statistical Findings

Variable	***Statistical Findings***
Lab Availability	15% of Madrasas
Adequacy of Lab Equipment	Mean = 2.1/5
Use of Supplementary Materials	<10%
Guest Teachers Employed	100%
Monthly Honorarium	₹6000
Student Interest in Science	78%
Student Lab Exposure	Only 35% ever did experiments
Awareness of NEP 2020 (Admins)	10%
Teacher Job Satisfaction	Mean = 1.9/5

The descriptive statistical findings—combined with qualitative narratives—underscore the serious challenges faced by Madrasas in delivering effective science education. The absence of permanent teaching posts, poor infrastructure, and lack of teacher training are core structural issues. However, the high levels of student interest and teacher commitment offer a foundation for improvement if adequate policy and resource support are provided.

DISCUSSION

The findings of this study reveal significant challenges in the availability and adequacy of resources for science education in Madrasas within the Tirhut Division of Bihar. While the National Education Policy (NEP) 2020 advocates for inclusive and equitable education, empirical data from this study indicates substantial gaps in infrastructure, teaching-learning materials, and trained personnel. These limitations hinder effective science education in Madrasas, a concern that echoes findings from prior studies on minority educational institutions (Rehman, 2017; Rizvi, 2016).

Resource Availability and Infrastructure Deficiencies

One of the most striking findings of this study is the inadequate infrastructure for science education in Madrasas. Only 15% of the surveyed institutions had a designated science laboratory, while 85% relied on general-purpose classrooms that lacked the necessary equipment for hands-on learning. Studies have consistently highlighted that well-equipped science laboratories enhance student engagement and comprehension (Yore et al., 2004; Banerjee & Duflo, 2011). The absence of practical learning facilities in Madrasas contributes to a learning environment where theoretical instruction predominates, limiting students' ability to develop essential scientific reasoning and inquiry skills (Iqbal & Alam, 2020).

Additionally, the findings suggest that basic science equipment—such as test tubes, beakers, and burners—was severely inadequate, with a mean availability score of 2.1 out of 5. This mirrors similar resource gaps observed in other studies on underprivileged schools and faith-based institutions (Zafar, 2015; Umar, 2018). The absence of ICT tools in all surveyed Madrasas further exacerbates the issue, as digital resources are increasingly recognized as critical components of modern science education (Nambissan, 2010).

Pedagogical Constraints and Teaching-Learning Materials

A significant limitation observed in this study is the over-reliance on state-prescribed textbooks— reported by 70% of science teachers. Supplementary materials such as science magazines, models, and experiment kits were used by fewer than 10% of institutions. Prior research has emphasized the importance of multi-modal instructional approaches for effective science learning (Ramachandran et al., 2005). The lack of diverse teaching aids in Madrasas creates a restrictive pedagogical environment where rote memorization prevails over conceptual exploration (Nasir & Farooqi, 2014).

Moreover, this study found that 65% of students had never conducted an experiment in their science classes, reinforcing concerns about the lack of experiential learning opportunities. This finding is consistent with previous research, which suggests that the absence of inquiry-based learning methods negatively impacts students' ability to develop scientific temper (Rizvi, 2016).

Challenges Related to Science Teachers' Employment and Training

The study's findings on teacher employment conditions underscore a critical structural challenge. None of the surveyed Madrasas had sanctioned posts for science teachers, with 100% relying on guest teachers who receive a meager honorarium of ₹6000 per month without job security. Such precarious employment discourages skilled educators from pursuing long-term careers in Madrasa science education (Ansari & Naseem, 2019). Studies have shown that stable employment and adequate compensation significantly influence teaching effectiveness and student outcomes (Alam, 2011).

Furthermore, only 25% of science teachers had formal pedagogical training, limiting their ability to adopt inquiry-based and interactive teaching methods. Rehman (2017) has previously noted that teacher training in Madrasas remains one of the most neglected aspects of educational modernization. Without structured professional development programs, teachers in these institutions continue to face difficulties in integrating modern scientific concepts into their pedagogy (Iqbal & Alam, 2020).

Student Interest and Learning Outcomes

Despite the infrastructural and pedagogical constraints, the study revealed high student interest in science, with 78% expressing enthusiasm for the subject. However, their learning experiences were

significantly hampered by inadequate resources and instructional methods. Students rated their overall science learning experience at 2.4 out of 5, highlighting frustrations related to the lack of practical exposure and

engaging learning materials.

This study's findings align with broader educational research suggesting that students in resource- constrained settings often display strong motivation for learning despite systemic barriers (Banerjee & Duflo, 2011). The positive interest levels observed in Madrasa students suggest that targeted interventions—such as providing laboratories, teacher training, and digital learning tools—could substantially improve science learning outcomes.

Implications of the Study

The findings of this study have far-reaching implications for science education in Madrasas within the Tirhut Division of Bihar, highlighting critical policy gaps, resource deficiencies, and structural inequities that hinder effective science learning. These insights contribute to broader discourses on educational equity, modernization of religious institutions, and the implementation of NEP 2020 in marginalized communities.

Policy Implications

The study underscores the urgent need for targeted policy interventions to bridge the science education gap in Madrasas. Despite NEP 2020's vision for equitable and inclusive education, awareness and implementation remain staggeringly low in Madrasa institutions. Key policy implications include:

- State-Funded Science Education Programs: Governments must initiate dedicated funding schemes to support laboratory infrastructure, science teacher recruitment, and digital resource integration in Madrasas.
- Recognition of Science Teacher Positions: The absence of sanctioned science teacher posts within the Bihar Madrasa Education Board suggests the need for formal employment structures that provide job security, adequate salaries, and professional development opportunities.
- Strengthened Monitoring and Evaluation Mechanisms: Establishing state-run audits of science education facilities in minority institutions can help assess implementation progress and ensure accountability in policy execution.

Educational and Pedagogical Implications

The study's findings highlight the systemic neglect of hands-on and inquiry-based science education in Madrasas, with limited practical exposure for students and an over-reliance on textbook-based instruction. This suggests that:

- A shift toward experiential learning methods is necessary to enhance student engagement and scientific literacy. This includes integrating inquiry-based learning, interactive science experiments, and ICT-enabled instruction into Madrasa curricula.
- Teacher training programs should be structured to equip science educators with modern pedagogical techniques, ensuring effective classroom instruction.
- Curriculum redesign can help align Madrasa science education with contemporary learning standards, incorporating contextually relevant scientific examples that resonate with student backgrounds.

Social and Economic Implications

This study reinforces the idea that science education is a key driver of social mobility, particularly for students from marginalized communities enrolled in Madrasas. The implications include:

- Enhancing employability prospects for Madrasa graduates by equipping them with scientific knowledge and practical skills necessary for higher education and technical careers.
- Breaking socio-economic barriers by integrating science education into faith-based institutions, empowering students with knowledge beyond traditional theological studies.
- Reducing disparities in STEM education access for minority populations, ensuring that Muslim students in Madrasas receive opportunities equivalent to mainstream educational institutions.

Institutional and Administrative Implications

The study exposes institutional inefficiencies in resource allocation, administration, and academic planning within Madrasas. The implications include:

- Strengthening Madrasa governance frameworks to mobilize resources for science education, ensuring administrators are aware of state and central education policies.
- Encouraging public-private collaborations to bring funding, expertise, and infrastructure improvements to Madrasa science education.
- Establishing regulatory mechanisms to track student learning outcomes, science curriculum implementation, and institutional progress in science education reform.

CONCLUSION

This study provides a comprehensive analysis of the challenges surrounding science education in Madrasas within the Tirhut Division of Bihar, highlighting critical deficiencies in infrastructure, teaching resources, and institutional support. The findings reveal that science education in these institutions is constrained by inadequate laboratory facilities, a lack of pedagogical training for teachers, and minimal access to modern teaching-learning materials, limiting students' ability to engage in experiential learning.

Despite these challenges, the study also underscores strong student enthusiasm for science, indicating a latent potential that could be nurtured through strategic interventions. Addressing structural barriers—such as improving laboratory facilities, ensuring permanent teaching positions, and integrating digital learning tools—could significantly enhance science education outcomes in Madrasas. Furthermore, the lack of awareness among Madrasa administrators regarding educational policies like NEP 2020 underscores the urgent need for information dissemination and institutional collaboration.

Policy recommendations emerging from this research suggest that targeted investments in teacher training, infrastructure development, and curriculum reform are essential to aligning science education in Madrasas with national standards. Government agencies, educational stakeholders, and community organizations must work together to bridge resource gaps and create sustainable frameworks that support modern science learning in these institutions.

Ultimately, ensuring equitable access to science education in Madrasas is not only vital for academic excellence but also crucial for fostering a scientific temper and intellectual empowerment among students from marginalized communities. By addressing systemic deficiencies and leveraging existing enthusiasm for science, Madrasas can emerge as meaningful contributors to India's broader vision of inclusive and quality education.

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