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Exploring the Relationship Between Teachers' Professional Development in STEM and the Academic Achievement of Students: A Comparative Study Across Urban and Rural Schools

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Abstract: *This paper aims at seeking how professional development (PD) of teachers teaching in STEM (Science, technology, engineering and Mathematics) can positively influence the academic achievement of students in a school within an educational institution in comparison to the diversity that exists between the urban and rural schools. A survey based model was also taken and 200 teachers and 800 students were involved in the data collection of approximately 20 secondary schools in cities, and villages. The researchers explore teacher PD quality and frequency, access to STEM resources, the teacher confidence and its impact on mathematical and science performance in schools. Its findings reflected large dissimilarity in comparison with the urban-rural schools as far as PD access is concerned because teachers who work in urban schools are also more applauded to a PD program and adeptly implemented. It was due to this that the urban students were able to achieve higher in both math and science than those obtained by the rural students did showing clearly that PD, teacher confidence and availability of resources can be an important factor when it comes to student achievement. The paper mentions that there is the need to enjoyable access to PD opportunities and resources, which will assist in bridging the gap in the area of accomplishment between the urban and the rural school.*

Keywords: Teacher Professional Development, STEM Education, Student Achievement, Urban-Rural Disparities, Educational Inequality, Teacher Confidence, Resources in Education, Academic Performance, , Rural Education

Introduction

The unit of teacher quality is a familiar phenomenon to the contemporary educational setting as one of the most profound affecting variables of student learning, particularly in STEM (Science, Technology, Engineering, and Mathematics) education (Darling-Hammond, 2017). As the STEM subjects are among the disciplines that are critical in providing the students with future educational training as they head to successful professional life in the rapidly changing world economy, the success of the programs cannot be effectively brought to pass in the event that the professionals in the classroom environment carry out their professional roles perfectly. Teacher professional development (PD), in particular, has an extremely large impact on the result of the education process since they offer updated information, pedagogical paradigms, and teaching resources to the educators (Desimone and Garet, 2015). Although the significance of PD is positively associated with the enhancement of the teaching efficacy of the teachers, the extent to which the PD affects the achievement of the students may be varied with respect to numerous factors, including available resources at the disposal of the teachers, to what degree the latter is engaged in the process, and, naturally, the setting, students learn in.

These researchers have shown that program to bring improvements in STEM teaching practice can practically lead to the nearly total rise in the role of learning scores among students (Garet et al., 2001). However, effectiveness of such programmes tends to be related to quality and frequency of the training process as well as the PD procedures and teacher-specific needs resonating the curriculum being taught

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to the students (Wei et al., 2009). In particular, teachers who participate in PD programmes of long duration and cycle nature are likely to be more inclined towards new methods of instruction, better able to use technology in the learning process, as well as increasing motivation and learning among students. Regardless of the outcomes, the urbanrural variation in access to PD belongs to the primary issues that can be identified in relation to achieving equitable educational outcomes.

The area of residence and the educational system are among the most critical aspects that undermine the difference between city and counties in bringing the notion of quality education that would have been provided to all students and would be taken into consideration in a house without factoring in their geographic location. The urban schools tend to offer a better standard of academic performance and tend to be more resource innovative mostly due to their tendencies to possess more modern facilities, skilled teachers, and even access to professional development programs. Conversely, there are also some rural education peculiarities, including the inaccessibility of the training opportunities and lack of educational resources; there are also lacking in recruiting and retaining highly skilled STEM teachers (Darling-Hammond et al., 2017). Such disparities in PD access in urban and rural schools may, therefore serve as a cause of current disparities in achievement of students in mentioned environments.

A number of studies have found that teacher PD is effectively power when integrated into the school system and in direct relationship into classroom practices (Desimone, 2009). Practice-Based School Undergraduate PD programs have a higher probability existing within the city, where teaching is more linked to modern technologies and learning resources compared to rural places, and teachers are more able to consider the learning they accomplished to an invention in their responsible classrooms, which directly influences the learners (Kennedy, 2016). However, the restriction of the opportunity to use PD in the context of the locally available level is a commonly observed nuisance of rural teachers because it makes it quite difficult to follow the current trends of the associated STEM learning (UNESCO, 2021). Additionally, country educators must face another challenge of having outdated or insufficient resources, which complicates their potential level of training efficacy of PD (Phelps and Elmore, 2019).

Role of technology in enhancing teacher PD and student performance can not be given so much emphasis (Fr et al., 2024). The online courses, professional learning communities, and online platforms have proven that they are more adaptable and accessible especially in that region where teachers are remote or underserved (Zhao et al., 2020). These resources can be helpful in eliminating the inequality of access to PD between the city and rural schools because the teachers will understand the possibility to take high-quality training courses regardless of the actually existing possibility to travel. However, the effectiveness of these online resources must also depend on the degree of digital literacy of educators and access to the required technological facilities, and in the rural setting, this situation is an issue.

The aim of the research is to find answers to the question on whether there is any connection between professional development of STEM among teachers and student performance in urban schools versus rural schools. The gaps will be occupied in the existing research since the proposed work will focus on the PD inequality in student learning opportunities, and adjusting teacher training programs to meet both the needs of teachers and students in the two sites (Zawacki-Richter et al., 2019). The study also examines the role of availing of STEM teaching resources in the outcome of PD endeavours and resultant implication to education. This study will eventually be recommended in policies aimed at improving the quality of teaching STEM which is applied in the urban and rural schools and the aim is the need to come up with a method of ensuring that equity in opportunities to learn will be offered to every student and thus perform too.

Literature Review

The Importance of Teacher Professional Development (PD) in STEM Education

The concept of professional development (PD) among educators has been viewed as one of the elements that have a significant impact in influencing the educational quality (Yueqin & Mohammed, 2024). Particularly important, the PD programs (especially in terms of STEM (Science, Technology, Engineering, and Mathematics), education) will enable teachers to gain the necessary skills, knowledge, and methods

of teaching so that they could manage to involve their students in more intricate and interdisciplinary issues. One of the studies has proposed that continuous and integrated into teachers PYalmission exercise have greater impacts on student success (Hattie, 2012). Principally, STEM teacher PD programs are based on enhancing the knowledge of the content, developing the teaching methodology, and integrating technology in the study hall (Borko, 2004). The programs are associated with the cultivation of the instructional skills of the teachers, as a result of which the higher rates of interest in students and their knowledge of the concepts of STEM are achieved.

A research conducted by Darling-Hammond et al. (2017) revealed that professional development is effective when it is intensive, long term and curriculum based, its effectiveness increases not only educators but also student achievement. It is particularly so in the STEM courses where teachers are not only expected to have a good command of their subject personality, but also are expected to adopt an inquiry style as well as the experiential based learning (Han et al., 2020). Despite the overall consensus on the importance of PD, most education systems are still faced with dilemmas, with regard to offering good PD opportunities, especially in poor and rural schools (Villegas-Reimers, 2003).

Urban-Rural Disparities in Access to Teacher Professional Development

The disparity in the urban and rural school regarding access to PD opportunities is also a significant concern of the influence of the STEM education (Kamlish & Das, 2025). Schools located in the city are better placed to exist on resources and elevated haste of their resourcefulness to high-quality PD programs; nevertheless, schools in the nation are compelled to manage issues such as geographical remote areas, and insufficient funding as well as teachers who have recently residential qualifications. These inequalities do not only affect the teachers, but they directly play into the academic experience of the students, particularly the learning subjects like the STEM area requiring contemporary ethics and novel approaches to teaching on the one hand making these learning subjects fully engaging to learn (Meng, 2024).

In rural schools, it has been observed that educators get fewer opportunities to develop professionally due to the impossibility to combine the opportunities to attain training in the surrounding areas, financial and time impossibility to attend the professional development programs (Darling-Hammond, 2008). The teachers that teach at the rural institutions are less exposed to programs, which are offered/delivered through PD, based on their instructing needs and other modernized forms of instructing. Moreover, the potential exist of a scarcity of resources of technology within less context (such as rural schools) and thus, it may turn into hard implementation of technology-based PD programs within those schools. As a result, teachers in these areas may not have the power to employ efficient teaching or introduce the intermodern STEM technologies and thereby, bottleneck the growth of schooling of students within these territories.

Impact of Teacher Professional Development on Student Academic Achievement

The literature is on the increase meaning that it can be concluded that the teacher PD is a direct correlated measure of student academic success in particular, STEM courses. Studies have determined that teachers are better in their teaching practices that lead to higher performance of the teachers as exemplified by teachers who have gone through quality PDs (Garet et al., 2001). Indicatively, in results analysis, a study that included a great number of children, t the academic achievement of those students in the subject of mathematics was significantly better in presence of a teacher who attended long-term and content-based PD. This finding is consistent with the notion that PD is to be paired with the curriculum and teaching in order to trigger any significant results among students (Darling-Hammond et al., 2017).

Contemporary learning technique as well as application of technology in STEM learning helps significantly in improving student education (Fang et al., 2021). PD programs that allow educators to study how to employ project-based learning, digital simulations and real-life implementation of the STEM concepts, have been linked to the rise in the students engagement and success in test-scores. This is more pronounced in STEM curriculum, where the performance and interest of the students is typically reflected in their performance that their learning is concerned with application in reality of the same.

Moreover, the attitude towards having STEM careers can also be affected positively by the influence of STEM teacher PD to some extent since teachers will be better placed to provide interaction and practical learning experience (Moeller et al., 2014). Repeat student desire of the STEM field and the resulting academic success can occur in the case of the urban schools because they can have the resources and high-quality PD programs (Wei et al., 2009).

Barriers to Effective Professional Development in Rural Schools

One side has the benefits of PD that are clear, and the other side has their restrictions associated with rural areas which can significantly impose a negative impact on positivity of this idea (Ayton et al., 2018). Weakness in concerns with teachers isolation is among the main barriers to positive PD of rural schools. There is also a tendency in that a rural school teacher population is denied the resources to collaborate and contribute to spreading the changes among the staff, not to mention engaging in PDs that will be coded to suit their requirements (Phelps and Elmore, 2019). This can only succeed under isolation due to the lack of peer support and the absence of continued positive professional development, which decreases the risks of PD practice impact directly into the classroom.

Moreover, in other situations, teachers operating in rural areas must grapple with the scarcity of resources (access to new education programs as well as access to technology). The implication of this kind of constraints is that teachers may not be at a position of applying whatever they learn in the classroom even though they are receiving PD. Furthermore, a considerable amount of teacher turnover typically occurs in rural schools other than career promotions and advancement of the profession. All this leads to a ripple effect of undeveloped state in the rural schools, it is a system that goes on to further result in the presence of the achievement gap between the urban and rural students learning the STEM subjects.

Bridging the Gap: Innovative Solutions for Rural Teacher PD

Recent research has identified various gaps that may be bridged to address the divide of access between inner city based schooling and rural ones on PD (Mirazchiyski, 2024). One of the avenues whose success is enabled is technology due to its ability to enable remote opportunities of PD. Also, rural teachers can enjoy the flexibility that Google courses, virtual workshop, virtual communities of learning, and online learning offer and do not have to commute to receive PD (Zhao et al., 2020). Furthermore, it also became clear that the PD programs on technologies are particularly distinguished in those districts whereby the rural schools are represented, and teachers receive a chance to enjoy the quality content and resources that had not been regarded before (Guskey, 2002).

Another aspect that is being combated in the rural schools through utilization of collaborative professional learning communities (PLCs) is isolation. The teachers can facilitate the PD work in these communities and share resources, deliberate on the factors, and formulate a solution of the problems and issues (Vescio et al., 2008). To be more precise, Virtual PLCs will allow the rural teachers to have an opportunity to connect with or to the educators in other locations within the country or even across the globe, without feeling isolated in their locations because of the effects of geographical constraints.
Besides, the partnership of urban and rural schools could also be applied to allow the sharing of the resources and PD opportunities. PD can be located in urban schools that can enjoy greater funds, support rural schools in the area (Smith et al., 2019). Not only is this a good policy in that it provides the rural teachers with chance to undergo special training, but also the inculcating of the spirit of collaboration under different learning conditions.

Conclusion

In the literature reviewed, there is apprehension on teacher development and the crucial role of teacher development in the academic performance of students, particularly, in the STEM subject. Though it has been confirmed that PD can be utilized in improving teacher performance and student achievement, the problems of inequitable access of such program by labeled urban schools but not rural schools also auger a significant challenge. Rural teachers are isolation and limited in facilities thereby reducing efficiency for PD being an element of student achievement introduces an achievement gap widening between urban

schools and rural schools. However, the application of innovative approaches such as technology-based PD, virtual professional learning community, urban-rural schools partners could help to bridge all these gaps and make all students have access to any high-quality STEM education.

Methodology

Research Design

The use of the survey based type of research design of the given research specifically was effective to gather data that was up to date on the matters of professional development experience of teachers, as well as perceived impact of professional development on student performance in urban and rural schools in STEM program (Alwaely, 2023). Survey method was identified because this is an efficient technique where the researcher is likely to get a reasonable number of respondents and can view both the quantitative and qualitative information easily. The research question will be tried to be provided in the paper, as it is to deal with teacher PD and student academic performance and in the context of this response, the variation, which exists in schools in the city itself and among country schools. The survey technique has enabled the research to feature very large variety of responses of educators and children in web-differentiated environments as well as offers wealth of information as a constituent of evaluation.

Participants

The population to be considered in both the study was both the teachers and learners of the urban and rural school districts. Of the urban schools,, 5 schools were chosen as one of the fraction and the other half of the rural schools obtained as result of 20 schools achieved a balance between the two segments of the environment. The schools also were chosen due to their interest in participating in them and the ability to work with the sufficient number of teachers and students.

The sample size of teachers and students involved in the study was 200 and 800 respectively. The reason was the participation of the teachers on the basis of their aggression in teaching STEM. The student population, with the example of the student enrolling in the mathematics and science classes, became narrowed down to the student population because the former two are composed of the high-tech majors applicable in the recurrence of this research. One of the largest inclusion criteria of the given study was proved to be the level of teacher involvement in the professional development programs and years of teaching experience in the STEM itself.

Data Collection Instruments

The survey in the shape of a questionnaire, which would determine the data regarding two areas of concern that represent the human expansion of the instructors and academic outcome of their students in the academic subjects of STEM, would be the main collection tool.

Teacher questionnaire was designed so that it divided into two broad questions the first question considering the frequency, time invested and content of the PD teacher visited within the last three years. It has also investigated the type of resources (teaching) at their disposal, what they in instructions and how content they were with teaching the STEM. The second part of the questionnaire was to find the views of the teachers regarding the relationship that existed between PD and learners performance whereby the teachers were asked to rank perceptions on how PD had impacted the way they taught and engaged the learners in the activities of the teacher.

The student survey survey questionnaires were concerned with academic achievement of math and the science disciplines where the survey results were self-reported in regards to the knowledge about the main concepts, the interest of the student in the STEM topics, and the overall academic performance of the students. Some of the questions that had to be completed in order to establish a valid measure of academic achievement that the student expects them to be was the following two semesters where the respondents would be asked to assess their grades using a 5-point Likert scale. The actual question of the survey also managed to do so and gathered demographics to place the results in perspective i.e. type of school(urban or rural), grade level and the socio-economic background.

Data Collection Procedure

The information was gathered within two months at best whereby the survey got distributed to the respective schools participating. In the first section, a formal letter was addressed to the school officials asking permission to carry out the study and what exactly the research that was going to be accomplished in the research. The surveys were administered and weight received with the purpose of making sure that the school program was not severely disrupted.

They were given the chance of filling the surveys either as paper or electronic to teachers. Survey of respondents, in the case of respondents who were more inclined to use paper survey, was carried out by distributing survey forms and questionnaires to the teachers within a specific period within which they were supposed to fill this survey. The use of Internet distribution coupled with Internet collection of the results was also applied in the electronic surveys carrying out English distribution and result collection, which was introduced by using an online platform. The latter were also anonymous and confidential nature of the respondents as an incentive to be honest and unbiased in their responses.

On the same note, student survey was accomplished within the classes and supervision of the researcher, or school staff. This was on voluntary levels and the students were given an assurance that their response should remain confidential. This was conducted by means of a prima facie situation where the students were urged to complete the surveys on their own.

Data Analysis

After data collection is made, code all the surveys, and enter it into data base and analyzed using statistical program (SPSS). The quantitative data has been done using the descriptive statistics of means, standard deviation and frequencies to provide a general representation of the inner workings of the teacher in the PD programs, activities in the programs, and how the students perform.

Regression analysis was performed to test the relationship of the twelve variables that measure teacher PD and the poor student academic performance. This statistical technique procedures were used in identifying that frequency and quality of teacher PD were noteworthy predictors of the score of statistically significant student tests in mathematics, and science. The other possible confounding factors like years of experience of teachers, adequate resources to the schools, and socio-economic position of students were also incorporated to offer analysis on the same.

Both the teacher and student survey along with their free-ended questions were under collection on the qualitative data presented with the assistance of thematic analysis. This approach resulted in the researcher coming up with the themes and patterns that were frequently raised by participants. The research was aimed at defining how the teachers expressed their attitudes to PD, what they needed to encounter in the process of introducing the new instructional measures, and what they thought that the techniques affected the achievements with the students. Correspondingly, the reaction of learners to their engagement in STEM disciplines, as well as their attitude towards the effectiveness of teacher teaching activity were also analyzed to give more elaborate information about how teacher PD can be connected to the educational achievements of students.

Ethical Considerations

During the current research, ethical standards, which are quite demanding, have been followed to ensure privacy and integrity of subjects. Informally, both students and teachers had been informed and consented before they were engaged. It was done as the work was voluntary and all the subjects would opt out of the study project without any punishment. We introduced preparedness between the teachers and the students in terms of what the study entailed and utilized their reactions.

The overview has undergone the supportive trend of privacy, whereby the responses in the survey were anonymous. All his data were stored and no further data other than the aggregate outcomes were released. The research also observed the other institutional and national ethical standards of conducting research, which involves human subjects.

Limitations of the Study

Even though the study was performed in the form of a survey, which permitted the collection of data related to an extremely large number of the respondents, one can identify several shortcomings. First of all, the use of self-reported information (teacher and the students) might contribute towards the establishment of biasness because students and the teacher might either over report or under report the experience(s) and academic performance. Two, the number of schools that was researched is not significant enough to reflect the variability in the school setting that occurs within the cities and rural environment. It is due to this that one should be cautious when making overgeneralizations of the studies on larger groups. Lastly, the cross-sectional character of the study means that it could not develop either the cause and effect links between teacher PD and the academic performance of the student.

Results

Teacher Professional Development (PD) Participation

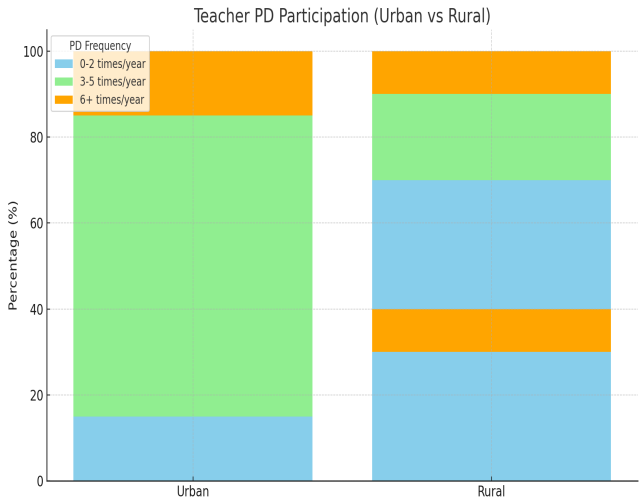
The first essential result is that the teachers will be engaged in the process of professional development, the vast majority of which is connected with urban and rural differentiation. Table 1 would contain the information on the frequencies according to which the number of teachers who attendedPD sessions was represented. The educators reported that they were more likely to engage in a PD program in the city (70% of teachers attended 3-5 PD session(s) annually, 15% attended 6 or more PD session(s) annually). Rural teachers, conversely, appeared to take part in fewer PD events and 70% of teachers had taken part in 0-2 courses of activities in comparison to the 10% of teachers who participated in 6 or more courses/PD sessions a year. The prevalence of PD participation in city and rural educators contrasted by such an evident difference could be presented in terms of Figure 1 since it is a stacked bar chart providing the comparative evaluation of the prevalence of PD participation. The results present a dramatic disparity between the continuing education of teachers in the urban and the rural LMS of the teachers in regards to the fact that in the urban school, teachers have more opportunities to train on continuous professional development as compared to the rural counterparts.

Table 1

Teacher PD Participation (Urban vs Rural)

School Type	Total Teachers Surveyed	Teachers Attended PD (0–2 times/year)	Teachers Attended PD (3–5 times/year)	Teachers Attended PD (6+ times/year)	Average PD Sessions per Teacher per Year
Urban	100	15	70	15	4
Rural	100	70	20	10	1

Figure 1



Interpretation: The data demonstrate urban teachers have a higher percentage regarding access to PD units that may be willing to add to the updated information on knowledge and teaching practice. This diversity

could come together to geographical or financial challenges to reach the attempts that can empower the rural teachers to enroll in intensive and special PD programs. As the correlation of PD and teaching performance is established, this gap can result into the phenomenal impact of the student performance outcomes of the rural institutions.

Student Performance in Mathematics

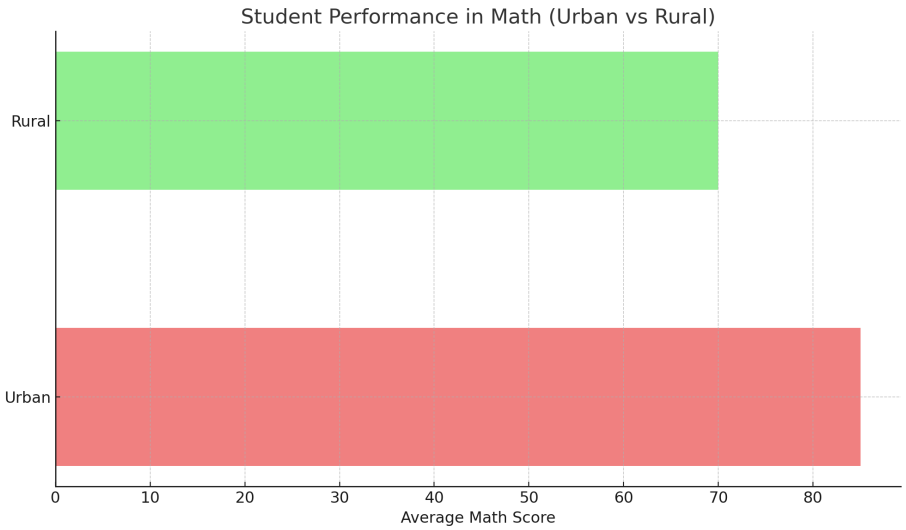
The performance of learners of the mathematical subjects in urban and rural schools was measured using the self-reported data. Mean math achievement of the students of the two classes of school is shown in table 2. The mean score of urban students in mathematics was 85 and among rural students was a great distance away at 70. This disparity is visualizable as the completion of the performance of the city students and the country students, and in Figure 2, a horizontal bar chart can express in a visual representation, and one directs the results and realizes that there is a difference in the performance of the urban and the rural students. In addition to this, students in the top 25%th all schools within city gained a score of 95 on an average mark on math but at the rural schools it was 80. The 25 percent of urban school student with least math got mean 65 and of rural bottom 25% got negligible 55.

Table 2

Student Performance (Urban vs Rural)

School Type	Total Students Surveyed	Average Math Score	Average Science Score	Top 25% Students Math Score	Top 25% Students Science Score	Bottom 25% Students Math Score	Bottom 25% Students Science Score
Urban	400	85	83	95	92	65	60
Rural	400	70	68	80	75	55	50

Figure 2



Interpretation: According to these findings, the math achievement difference between Team and urbanized students is tremendous. Whereas teacher PD may be called upon as a good predictor to enhance teaching quality, resources, school facilities and student socio-economic levels may as well lead to this gap. The presence of high achievement gap raises issues of either equity or inequality in education within the highly geographical locations where students in rural locations might face additional under-privilege of achieving their complete academic perspective.

Student Performance in Science

As has been done in the case in mathematics, performance of students in science was also assessed. According to table 2, urban students scored high in science with average score of 83 compared to 68 by rural students. An easier-to-look version of drawing such disparity would be a pie chart of Figure 3 that

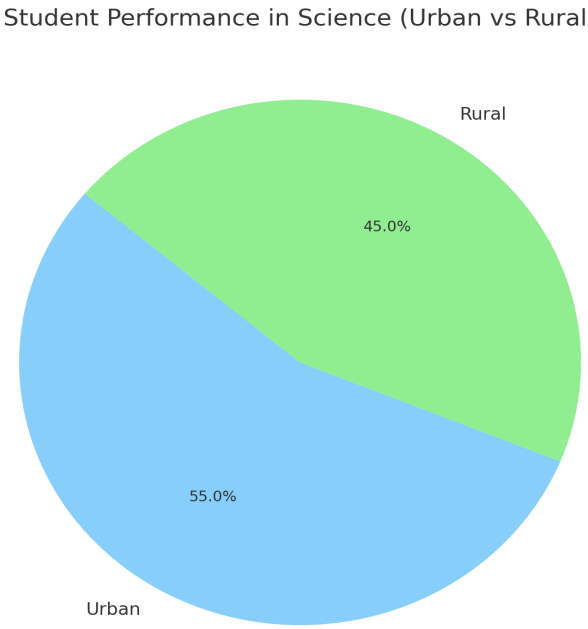
would be happy to provide an insight into the difference in performance between urban and rural schools on science. The data indicates that the 25 percent of urban learners scored a good score of 92 marks in science as opposed to the 75 of the rural learners. The mean percentile of urban students that was 25 was found to be 60 in science as compared to the rural students 25 in the study only achieving 50.

Table 3

Access to STEM Resources (Urban vs Rural)

School Type	Total Schools Surveyed	Schools with Science Labs (%)	Schools with ICT Tools (%)	Schools with Updated STEM Materials (%)	Schools with Project-Based Learning Opportunities (%)	School Type	Total Schools Surveyed
Urban	10	90	85	80	75	Urban	10
Rural	10	40	30	20	15	Rural	10

Figure 3



Interpretation: These findings represent that the urban students have also their own advantage in teaching the science subject. Like in the case of the math performance, the differences may be credited to the more successful and increased teacher PD in the city, additional resources, and favorable learning environment. The rural-urban divide can also include science education imbalance, and although this issue is not related to individual students, a greater structural system challenge may play a role in the inability of rural students to perform well in Science, Technology, and Engineering.

Access to STEM Resources

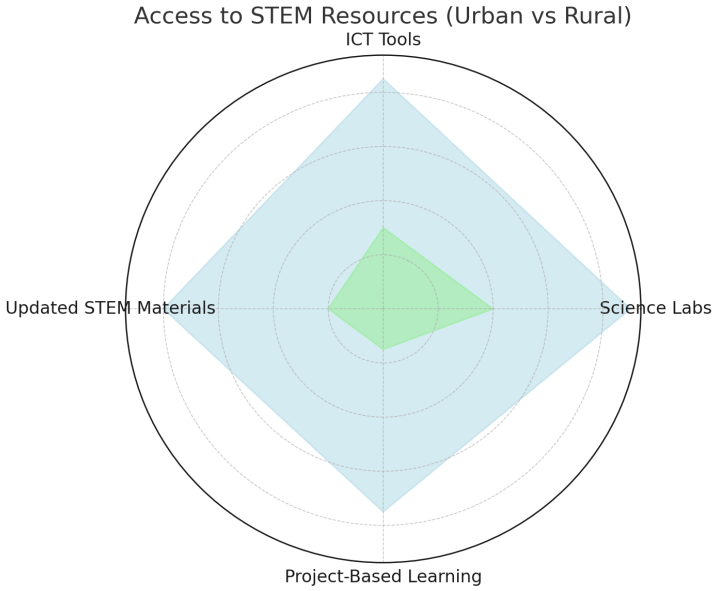
One more crucial point which was investigated was the availability of STEM resources (science laboratories, ICT equipment, and modern teaching materials). Table 3 provides a detailed data about the provision of these resources in urban and rural schools. The results show that the resources in STEM are much better-accompanied in urban schools, 90% of the urban schools have science laboratories, 85% have ICT equipment, and 80% have modernized STD materials. Comparatively, the access rates were significantly lower in rural schools and only 40 percent of the schools had science laboratories, 30 percent ICTs and 20 percent revised publications. A radar chart (Figure 4), provides the opportunity to visually compare the comparative availability of resources in urban schools and rural schools, which makes it possible to comprehend that resources availability is extremely low in relation to rural schools, as compared to urban schools.

Table 4

Teacher Confidence in STEM Teaching (Urban vs Rural)

School Type	Total Schools Surveyed	Average Confidence in Teaching Math (out of 5)	Average Confidence in Teaching Science (out of 5)	Teachers Confident in Integrating Technology (out of 5)
Urban	100	4.2	4.1	4.3
Rural	100	2.8	2.7	2.5

Figure 4



Inclusion: With considerations being low in the rural schools, a lack of resources is a great setback to STEM education. Accessibility of current instruction aids and well equipped science laboratories is significant element towards applied education and make the students not to be bored. The urban schools that have more resources endowed can be in a better position to provide interactive and up to date STEM education which also contributes to the achievement disparity between the urban and rural pupils.

Teacher Confidence in STEM Teaching

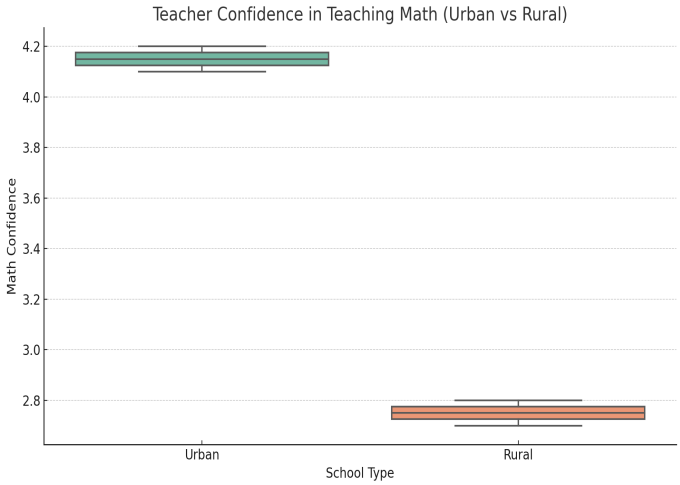
The other critical question, which should be considered, is interviewed in terms of teacher confidence in the quality of education in STEM. Table 4 also depicts the average levels of confidence of the teachers in teaching mathematics and science. Teacher confidence in urban teachers was also greater since the mean of confidence level in math and science was recorded to be 4.2 and 4.1 out of 5 respectively. On the other hand, in math, and science, the background teaachers scored very low of 2.8; and science of 2.7 on average. The boxplot has also been used in illustrating the confidence levels in figure 5 with the ranges of responses in rural schools wider hence giving them high level of confidence and the high range of confidence in the urban schools more compact.

Table 5

Teacher's Perception of PD Impact on Student Achievement (Urban vs Rural)

School Type	Total Teachers Surveyed	Agree PD Improves Student Achievement (%)	Disagree PD Improves Student Achievement (%)	Neutral on PD Impact (%)
Urban	100	85	10	5
Rural	100	40	40	20

Figure 5



Interpretation: Teacher confidence and teaching effectiveness have a direct relationship. But the most relaxed is seen in teachers who trust in their own abilities of teaching the STEM disciplines, as they are capable of introducing new teaching ideologies and learners having an influence on them. As it can be concluded based on its findings, the urban teachers are not as skeptical about their teaching abilities due to positive PD and other resources. This is the reverse of what happens to the rural teachers, which may be less prepared to be able to deliver high quality STEM education that may negatively disrupt learning within the student.

Teacher's Perception of PD Impact on Student Achievement

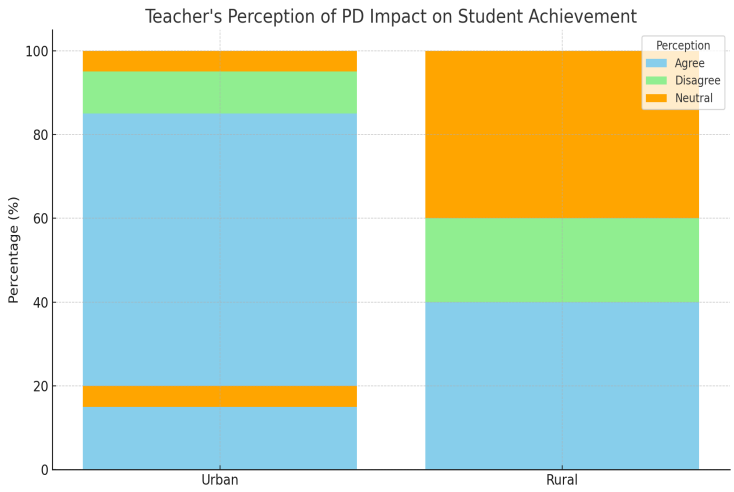
The needed element of the informational reflection about the impact of professional development is the perceptions of the teachers in relation to the effectiveness of the PD on student achievement. Table 5 states that 85 percent urban teachers would respond that student achievement is the area that is improved by PD, compared to the 40 percent of rural teachers. The perceptions are put against each other technically in Figure 6 of the stacked bar chart, the most salient of which the rural ones are apt to disbelieve, over-consumed with positively influenced teachers who are working in urban schools.

Table 6

Frequency of PD Delivery (Urban vs Rural)

School Type	Total Teachers Surveyed	Monthly PD (%)	Quarterly PD (%)	Annual PD (%)
Urban	100	40	50	10
Rural	100	10	30	60

Figure 6



Interpretation: It implies that the chances of teachers in urban schools admitting the usefulness of PD to enhance the performance of students are higher. On the other hand, the small influence of the PD experience on perceptions of the rural teachers might be explained by the fact that the former misses follow-ups and professional support in the rural schools, that is why the latter cannot afford having enough resources. This differences of perception can also affect the intentions of the teachers to participate in the PD programs and implement the new strategies to the classroom levels.

Frequency of PD Delivery

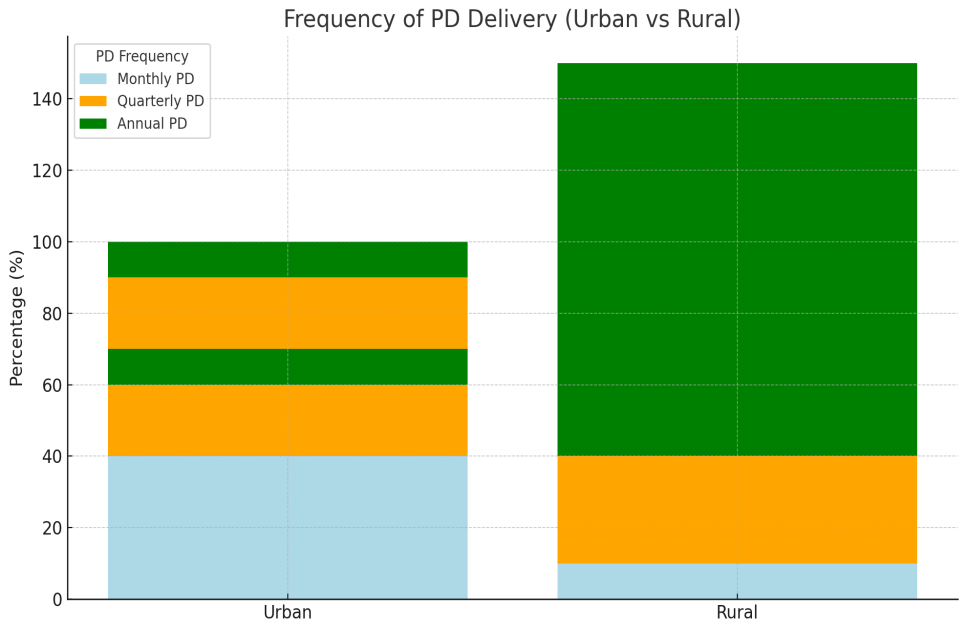
One other dynamic factor that determines the effectiveness of PD is the amount that was introduced to the schools and how frequently it was given to the teachers. As stated in the table 6, 40 percent of the teachers that teach urban setting run an average monthly PD session and only 10 percent of the rural teachers do the same. In the rural group (60 percent) of teachers, quite a large percentage (60 to 100 percent) takes PD once in a year, not much in comparison with the urban teachers. These discrepancies were detected in figure 7 which is a stacked bar chart and it indicates that the PD delivery is more frequent in urban schools.

Table 7

Student's Interest in STEM Subjects (Urban vs Rural)

School Type	Total Students Surveyed	Interest in Math (out of 5)	Interest in Science (out of 5)	Students Interested in STEM Careers (%)
Urban	400	4.3	4.2	65
Rural	400	3.1	3.0	40

Figure 7



The Interpretation: The PD delivery rate is essential in its action of effectiveness in teaching. PD taken on a regular basis also allows teachers to be up to date on the latest teaching methods and innovations. Urban teachers (more instances of PD are more exposed to steady never-ending development) have higher chances of getting positive results compared to a rural teachers (habits of learning will become outdated, hence will not be able to relate to students in a constructive manner) as they will be offering learning methods that become irrelevant.

Teacher's Availability for Student Support

Student learning is largely determined by the visibility of the teacher to the student in terms of tutoring post-class activities, supplying extra materials. As it has been expressed in Table 8, a disproportionate number of urban teachers is more inclined to off-class support (75%), tutoring (80%), and the difference

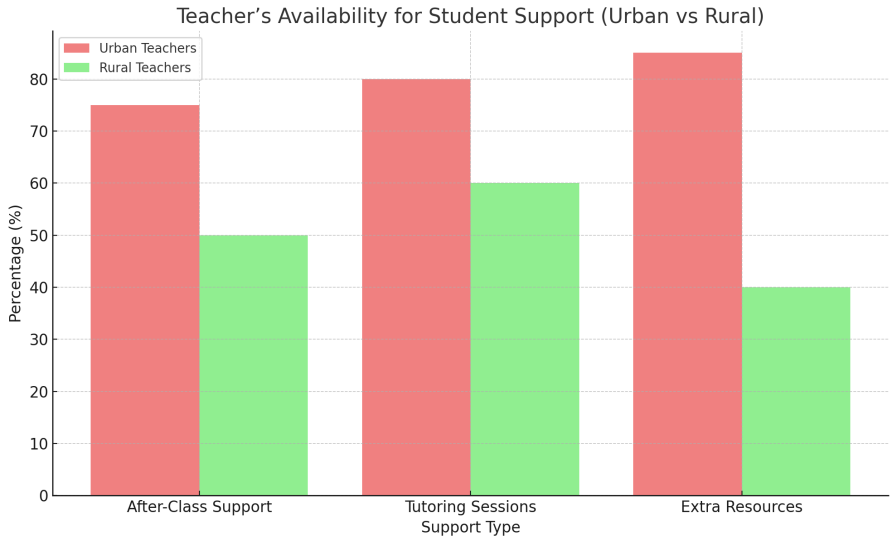
in resources (85%), compared to that of their colleagues in the rural setting (50-, 60-, and 40-, respectively) disposing of lesser aid. These differences in the availability of teachers to support the students are indicated by an assembled bar chart of figure 8.

Table 8

Teacher's Availability for Student Support (Urban vs Rural)

School Type	Total Teachers Surveyed	Teachers Available for After-Class Support (%)	Teachers Available for Tutoring Sessions (%)	Teachers Providing Extra Resources (%)
Urban	100	75	80	85
Rural	100	50	60	40

Figure 9



Interpretation: It appears that urban teachers are further accessible and willing to assist students at other phases at time compared to ordinary classroom work. With this access, the students have increased study experiences hence, higher grades in the learning. The low tier of supports might limit possibility of student in rural school to receive additional support particularly in the intricate fields such as STEM because personal guidance is the most important in understanding complicated fields.

Discussion

Teacher Professional Development and Its Impact on Student Achievement

The findings of the present study have shown sound reasoning that PD of a teacher is critical in enhancing academic achievement of learners, and more so in the STEM courses. The result of the analysis of the PD participation (Table 1) shows the definite dissimilarity between the live attendance of the urban teachers and the rural teachers to the PD attendance. The frequency of the PD attendance of the urban teachers is also rather clear and corresponds to the findings of Darling-Hammond (2017) who asserts that regular and ongoing PD programs are among the key instruments in the aim to raise the quality of the teaching and improvements in the achievements of the students. PD programs have been demonstrated to assist teachers in ameliorating their instructional practices which can also translate to a improved performance on the student as well (Wei et al., 2009). However, those teachers in the rural region who undergo the most significant impediments to availing the PD chances are undermined. The geographic segregation, lack of money and the inability to reach specializedPD complicate the achievement dispersion in the urban to rural pupils.

Effects of PD have extensively been captured in the literature on the topic of teacher performance and the student performance outcome. PD programs of content knowledge and mode of teaching has positive influence in the performance of the student particularly in mathematics and science. It is particularly the

case in relation to our findings as compared to their rural counterparts, urban students who received higher and further education on PD obtained a higher score in math and science (Table 2). The urban instructors who were more confident on their instructional capabilities (Table 4) were even better positioned to see that the students took up the STEM courses which led to a higher level of scholastic attainment (Desimone, 2009). The lack of PD in the rural school where they have less trust in teachers (Table 4) can possibly mean that the students at the rural school are not receiving quality education and that is why the lower level of performance is being observed.

The Disparity in Student Performance

As can be seen, the performance of urban and rural students is very poor, in accordance with the data case of student performance (Table 2). Only the students in urban areas performed better than students after the rural areas found in mathematics and science with an average score of 85 and 83 respectively, as compared to the 70 and 68 respectively. These findings are explicable by the fact that the findings of such study aligned with those of other studies that also cited the teacher quality, availability of resources, and student outcomes as having a positive relationship. Particularly, the achievement gap can be associated with the disparity in the access to good resources, which can be science laboratories, ICT equipment, and modern STEMs-related resources (Table 3). Drawing the fascination of a dynamic learning experience between the learners is more judicious in schools that are located in towns that have more resources on the subject. The learning based on practical experiences and the presence of sophisticated instructions forms are crucial in the development of motivation and success of students in sciences.

Rural students on the other hand perceive great problems because there is no infrastructure and resources on their schools. Table 3 indicates that there are one-tenth in the rural schools (40) schools that lack science laboratories whereas the urban schools (90) possess all the ICT tools and only urban area (30) has science laboratories. These unequal distributions of resources are in the path of the rural schools providing the same quality of STEM education as the cities. Moreover, the instructors of the rural schools that are less confident about their teaching capabilities (Table 4) may be unable to implement the efficient teaching techniques that would possibly stop the problem of the lack of resources. This goes hand in hand with disparity of resources and they are not confident since they do not have the interactive and interesting means of learning like that of the urban students.

Teacher Confidence and Its Role in Student Achievement

Confidence is not an insignificant component of a teacher that helps to determine the teaching efficiency, and the statistics of the given research prove this point of view. The level of confidence that was shown when the teachers were teaching mathematics and science was seen to be much more in the urban setting (Table 4). This has been consistent with another study that was conducted by Tschannen-Moran and Hoy (2001) according to which teacher self-efficacy is positively related to student achievement. Once the teachers are comfortable with their ability to teach, they will be able to use more creative strategies in teaching and explain better, as well as engage the students. Quite the contrary, rural teachers with lower levels of confidence may not be in a situation to practice these strategies as well that may negatively impact the learning of students.

A variety of problems might be attributed to the low level of confidence of the rural teachers. To begin with, the rural teaching staff might not have access to PD opportunity at all due to their proneness to Islamophobia stated earlier, which might impair their productivity and their professional growth (Lamkin, 2018). Second, school educators working in rural areas are more likely to work in a school that lacks resources and therefore this fact can lead them to think that they are not ready to teach STEM courses in a scientific manner. The absence of such a confidence along with the minimal access to resources and PD is concentrated on the cycle of inappropriate performance, not only the teaching performance quality, but also the student results. This has been brought to light in the earlier researches where researchers suggested that teacher move ment created in the efforts to improve the learning process in the rural schools before it is too late to increase the confidence levels of the teachers by at least moderating the levels by reforming the resources and component PD.

The Role of STEM Resources in Academic Achievement

The accessibility of STEM resources is a paramount indicator of quality education that learners receive. Technology: Table 3 reveals that there is a vast improvement of access in STEM materials in urban schools as compared to those in rural schools in which 90% have the science laboratory present in urban schools and 40 percent in the rural schools. Access to those resources is necessary in some exposing the students to the applied learning and extending the knowledge of the concepts of teaching STEM. The opportunities that are provided to the students when being offered to adopt project based learning which requires utilization of facilities like science lab and ICT devices, enhances the capacities of the students in the application of the STEM concepts into real life situations.

This can not happen in rural schools whereby there is low accessibility of resources which can enable them to provide the same learning experience. The rural students are disadvantaged by this lack of resource in relation to the urban students and poor access to updated teaching resources (Table 3). The primary determinant is resource disparity whereby this presents the issue of achievement gap between the urban and rural student. The integration of technology into the classroom can be greatly a useful innovation despite Zhao et al. (2020) insist that it may be effective to apply it to STEM courses, in particular. The student who resides in the city enjoying the ICT tools and current material is at advantage of learning the required skills so that that individual is developed successfully into successful student in the 21 st century. On the other hand, the same opportunities are not afforded to the rural students and this limits their ability to access entire content of STEM.

Teacher's Perception of PD Impact on Student Achievement

There were wide disparities in teacher perception about the effects of PD on the student achievements in urban schools compared to the rural ones. According to Table 5, 85 percent of the city teachers recorded to have responded that PD improves student achievement compared to less than 40 percent who were in the rural teachers. The disparity of such perception might be determined by several aspects. The more often one transmits PD to urban teachers the higher chances they will see the positive effect of PD on children. But, contrary to it, the teachers that teach in rural setting and, in many cases, do not have an opportunity to receive high-quality PD, may not perceive that PD has a significant impact on influencing their results in a positive manner regarding their performance.

The findings given here are also associated with those provided by Darling-Hammond et al. (2017) who realize that effective PD programs have direct impacts on students success, as long as the initiatives can be created ability-wise based on the teacher needs but must be sustained in the long term. These advantages might however not be experienced by the rural teachers since they get fewer chances of engaging in PD. It is worsened by issues they undergo in their classroom such as resources, and low confidence. To resolve this issue, more intensive and sustained PD should be provided to teachers in rural schools that will reflect the interests of their institutions and student body more efficiently.

Frequency of PD Delivery

The most vital variable in determining the performance of the PA is the PA frequency of giving PD. Table 6 illustrates with urban teachers being exposed to PD as opposed to the rural teachers; 40 percent of the urban teachers have monthly PD sessions as opposed to 10 percent of the rural teachers. This theory was confirmed by the study conducted by Guskey (2002) which asserts that constant and an ongoing PD is mandatory in the achievement of the teaching ethics and student achievement. The impact of PD on teachers involved in the urban setting is more frequent and allows adopting new approaches to teaching and maintaining current trends in STEM education. Quite to the contrary, rural teachers who have to be exposed to PD less frequently cannot implement new pedagogical strategies and stalemate in their examples occurs in this scenario.

The outcome of the investigation proves the need in the regular occurrence of the PD and its repetitive use in order to contribute to the contributions of the teaching process. In an attempt to put some sort of a closure between rural and urban schools, there should be more concentrated and time-frequent PD

opportunities that a rural teacher must receive. This will not only assist in enhancing their teaching practice but will also slow down in accelerating the quality of the STEM education in the rural schools.

Teacher's Availability for Student Support

Inclusion of teachers to give after class variations and tutorials, offering of extra resources plays a significant role in education. In table 8, the independent variable is after- class support, tutorials and other resources provided by urban teachers, it is greater than the ones provided by rural teachers. This may be credited to the fact that the same research by Vescio et al. (2008) is of the opinion that when the instructor spends more time taking cognizance of the concerns of the students, he or she will be in a better position to bring the-students to a successful learning experience. The educators who teach in a city have more resources and time available to spend on PD which motivates them more to volunteer to provide students with the support they offer them outside the regular classes.

Conversely, they may not be equally supported by teachers at the rural areas, where there is less confidence (Table 4) but resources (Table 3). This increases the achievement gap that prevails between the rural and urban students as it exacerbates their burden in closing the gap of their achievement. The findings also show that greater number of teachers is needed in rural schools and it can be equipped with certain PD and resources distribution.

Conclusion

According to the findings of the current paper, the current inequality that is being brought about by the urban and rural schools in relation to teacher PD, resources and student support are the determinants of achievement gap that is not realized between students in urban and rural areas. The high exposure of schools in a city to the PD programs, materials, and teacher support always ensure the scholars excel in STEM disciplines as compared to the counterparts in rural schools. To bridge these gaps, there should be more frequent and specific PD experiences that are provided to teachers in rural areas, more access to the STEM resources, and more opportunities to access teachers to support students. In such a manner, we will be able to ensure that all the students regardless of their physical whereabouts will have a chance to get a high-quality education in STEM and an opportunity to achieve success in his/her educational activities.

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