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PERVASIVE COMPUTING TECHNOLOGY TO SUPPORT EDUCATION DURING ADVERSE SITUATIONS IN BANGLADESH

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ABSTRACT

Education is a humanitarian right. The alarming increase in armed conflict, forceful displacements, health, and climatic disasters, along with other crises dramatically impact the education system in the long term. Pervasive computing technology can provide a smooth interaction to support education during a crisis. The paper, therefore, aims to discuss the support that pervasive computing technologies can provide during a crisis for the Least Developed Countries like Bangladesh with the least possible cost. The paper highlights different real-life cases in Bangladesh and then uses secondary data from 2006 to 2020 to understand the relation at the times when education was hampered for the adverse situation. Based on the findings the importance of the application of pervasive computing and necessary recommendations are given which may help the state and locals in responsibility to support education at such times**.**

Keywords— Education, technology, pervasive computing technology

I. INTRODUCTION

The developing countries will remain mired in poverty unless they walk along the pace of the era. The more they preoccupy with widening techs and innovations the more they can develop their nation. The essence of the computer has become so much swelling that a person cannot think of a single moment without it. Even the earners below $1025 in the least developed countries in Bangladesh are using devices like smartphones, and TVs. The government has facilitated Information and Computer Technology in the education system throughout the country. The citizens irrespective of their income have huge scope to enlighten them with innovative research and work to thrive in their lifestyle.

Unfortunately, the world is facing a learning crisis. Adverse situations take place all over the world. But when the country is disaster prone like Bangladesh, education becomes tougher. The government is ensuring that every child has significant access to education, but being in school and learning is not the same thing. Thousands of children around the world are reaching adulthood without even knowing basic skills like calculations, taking the correct changes from a transaction, reading doctor's instructions, and even facing difficulty in understanding a simple bus schedule[1]. If the generation is facilitated with good education, it benefits both society and individuals.

Education raises self-esteem and opportunities for employment and earnings. Countries can also drive long-term economic growth, spurs innovation, and reduce poverty. So, when education gets hampered, the children lose a huge opportunity to learn their basics as they get lost track of a lot of lessons as planned by the curricula. They get less time to cover the lessons, and their learning is not as beneficial as it should be. Technology is already playing a crucial role in human life, and it can be better used to support teachers, students, and the learning process. The teachers can manage lessons better even when the schools are closed, the country is facing distress, education is under attack or any challenging situation.

Technology can be used to interact seamlessly in adverse times. If the governments of Least Developed Countries like Bangladesh use technology in the education system rather than traditional methods, millions of students can be benefitted. Focusing on two basic research questions why pervasive computing is needed and how it supports education, the paper aims to discuss pervasive computing technology that can be too supportive to education in adverse situations.

II. LITERATURE REVIEW

All individuals have the right to be educated. Education can be lifesaving and life-sustaining. Bromley & Andina [2] reported that children and adults have the right to be educated during emergencies and all possible steps should be taken to alleviate human suffering arising from conflicts and calamity. If individuals are educated, they get the ability to heal from bad experiences and be skillful to tackle conflicts or disasters, and support conflict resolutions to build peace.

Mobile phones act as the best technology that provides strong support for educational strategies with competency and performance-based curricula during adverse situations. Hasan et al [3] highlighted smartphones as a medium to provide education in the distance learning process. Norman [4] discussed the impact of pervasive computing in education and anticipated the importance of smart teachers and smart students. The researcher proposed an education framework where knowledge is permanently available. The researcher suggested a knowledge box that transmits data in the body and transmits signals to the brain. Classroom teaching will be replaced by digital devices sooner or later. So, the process may start now as the world is facing chronic situations and education is facing distress. McCarty [5] demonstrated the different levels of learning in Japan using pervasive computing technology. In Japan education is embedded in systems in various products. They also use plastic wristbands to offer in-patient safe medical care. The student's attendance management system, score assessments, and study-related data are managed through pervasive computing. The author highlighted the examples as a potential application to educational developments using pervasive computing.

Smart Classrooms facilitate learning among students. Yau and Karim [6] in his paper suggested using Reconfigurable Context-Sensitive Middleware (RCSM) to improve the quality of instruction and improve teaching qualities. The researcher suggested using pervasive computing as an embedded, handheld, and wearable device that is wirelessly connected. Khan et al [7] reported that Information and communication technologies have been effective educational technology that promotes dramatic changes in the learning and teaching process. Noor et al [8] proposed a cloud computing architecture to overcome the drawbacks of the education system and opportunities of distance learning to carry out courses while balancing other commitments.

III. METHODOLOGY

The paper analysis data using qualitative data. The researcher develops casual explanations by studying the cases of different events to understand how education is greatly hampered in adverse times. Then a time series diagnostic analysis is made of the statistical data from 2006 to 2020 to validate the cases when education is affected. Therefore, the paper provides a comprehensive overview in understanding the impact of pervasive computing on education during adverse situations concerning education settings.

IV. DATA COLLECTION

The paper mainly focuses on secondary data. The data for cases are collected from different national and international newspapers, journals, and web pages. The data for time series analysis is collected from World Bank data, Statics Times, and Index Mundi website.

V. FINDINGS AND ANALYSIS

Pervasive computing technology can be a great scope for the students in Bangladesh to educate themselves with the necessary skills without their education getting hampered. The paper, therefore, highlights the scope through the following two research questions.

RQ 1: Why pervasive computing is needed to support education during adverse situations in Bangladesh?

RQ 2: How pervasive computing can support education during adverse situations in Bangladesh.

Based on these two Research questions, data is collected and analyzed. The first question analyses different cases and then analyses the data relating to the trends over the years reviewing the ways education hampered in Bangladesh over time. From those specific cases and analyzing the time series data, the change in educational trends is identified. Then the second question suggests different techniques which can support education in developing countries like Bangladesh. The second question discusses on the usage of pervasive computing and a generalize the idea in Bangladesh prospects.

A. **Reasons pervasive computing is needed to support education during adverse situations in Bangladesh**.

To understand the importance of the need to include pervasive computing as a prime method to support education, four cases are studied and analyzed.

Case 1: Severe Political Unrest leading shutdowns

Bangladesh faced serious political turmoil in 2015 between the two main political parties that largely affected Bangladeshis education. In a content published by UNHCR [9], it is documented that explosive devices were used in target schools when the institutions were used as polling stations in January 2014. The campaigns hurt the entire country and mostly the students as the shutdowns were before examinations.

During that time extremist violence affected education resulting in school attacks on universities, students, and teachers. The attacks were reported in the early years but peaked in 2014. Human Rights Watch [10] reported that around 553 educational institutions were damaged by elected-related violence in those years. The paper also reported multiple attacks on educational premises. After one of the political parties became influential and the attacks on education were harshly dealt with, the rates of attacks gradually decreased over the years. Not only this, every year, even in months, the villagers face land disputes, rural fights, and many more for which the underprivileged often must miss their classes. Schools remain closed for years.

Case 2: Pandemic and different contagious diseases.

The worldwide education system is seriously affected by the COVID-19 pandemic. To control the spread of the virus, schools, colleges, and different educational institutions were shut down which ultimately brought difficulty for the students and teachers. Time evolves a new era of distance learning to continue the education system. But lacking internet connections, infrastructures, technologies, and network access made it more challenging.

Arora [11] found in his investigation that in the last two years, not only in Bangladesh but 147 million children around the world lost learning opportunities. As the pandemic ended, children had to return to school, but it needed to ensure they start with foundational basics which is a great loss and hectic for educational years. If education was not hampered, then this loss would easily be recovered.

In Bangladesh, different diseases are found to be spread which causes the local people to reside in their homes for a specified time. The common viral diseases are tuberculosis, malaria, and different neglected tropical diseases like leprosy, kala-azar, etc.

Case 3: Natural Calamity as an adverse situation for education

Amongst all the South Asia counties Bangladesh is one of the disaster-prone areas for its geographical nature, complex topography, monsoon climate, mighty river system, and coastal morphology. Baten et al [12] reported that the country faced 297 natural disasters from 1972 to 2018. The country has adopted different educational programs from its initiation till now, but the ever-changing climate of the country often leads to natural disasters like floods, cyclones, erosions, and many more that severely affect the children's education. Adul and Oli [13] reported in UNICEF that 900 schools were damaged by these natural calamities which disrupt the education of more than 1.5 million children.

Case 4: infrastructural issues in rural and urban areas

The educational institution in Bangladesh often demands infrastructural developments. Sometimes these institutions get crashed by natural calamities or hamper education for roads, railways, and many other developmental works around these educational institutions. All these cases hamper education from a day to even months. The noise pollution from infrastructural developmental works also disrupts education and deviate students' focus on learning the actuals.

All the above cases highlight that affordable technologies can come as a great blessing for the education system in Bangladesh. In a year, if people are bound to stay in their homes for continuous two to three months because of natural calamities, different unrest situations, or any other adverse situations, as seen over the last few years, education can be damaged, creating a less fruitful and fewer knowledge citizens, that in turn is remarking for the whole nation. So, to survive the nation, surviving the education system is a must. The most adverse cases are seen on or before 2014 are counted and the pandemic years from 2019 to 2021 are analyzed to see the changes in educational aspects amongst the

children of Bangladesh. Based on the cases a time series analysis is made to identify the extent education hampered in these years, and if the cases are related to creating critical situations for education.

Individuals using the Internet (% of the population)

The Internet has been established as a very important tool that promotes self-study. People around the world have showcased their talents, educated themselves, and discovered various latest information using the internet. During the pandemic, the internet has been the most supportive technology to help education continue, even in developing countries like Bangladesh. The Internet has become a part and parcel of common citizens' life and people are now more used to it. People using the internet means they have devices that can be used in adverse situations to help studies continue. An analysis made by Kemp [14] stated that the number of internet users in Bangladesh has increased by 11.6% which is 5.5 million people between 2021 and 2022. At the beginning of 2023, the number of internet users in Bangladesh was 66.94 million, which is 38.9 percent. At present, the population in Bangladesh is 168.30 million as of March 9, 2021 [15]. So, we can see a significant number of people are adapted to internet access irrespective of the network quality.

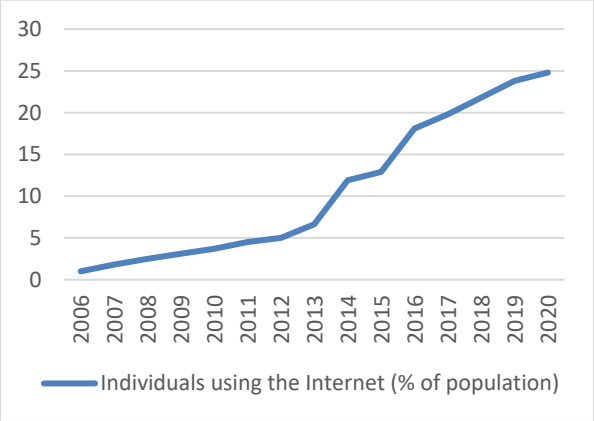

Figure 1.: Individuals using the Internet (% of the population) [16]

From the graphical illustration, it is seen that from 2006 to 2020 the number of internet users has significantly increased. This means children whether using the internet or not, their guardians or people surrounding them are using the internet, which can act as great support for pervasive computing for education. So, if proper technological reforms are provided pervasive technology can ensure that education continues even when the country undergoes adverse situations.

Government expenditure on education

Amongst the 39.7 percent children in Bangladesh, 30 to 35 percent are first-generation learners [17]. These students receive very little financial support from their families and depend wholly upon the school for their education. The government therefore should spend more on education. If the country hesitates to invest and improve the education system from now on, it will be difficult for Bangladesh to reach sustainable development and educational goals by the world pace. This would jeopardize the achievements of Bangladesh in education sectors like universal access to primary education, gender parity in education levels, ICT-based classroom activities, teaching and learning in five ethnic languages, the Braille system, etc.

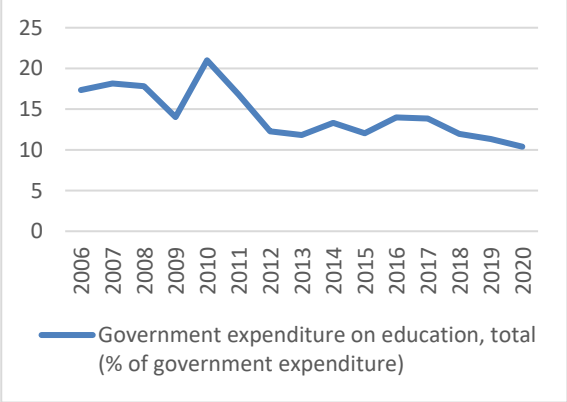

Figure 2.: Government expenditure on education [18]

From the above illustration, it is seen that from 2006 to 2020 the expenditure of the government on education has comparatively decreased over the years. A major dropdown is seen in 2009 while it suddenly rose in 2010 and again dropped till 2012. The lowest expenditure is observed in 2020. Mentionable that, from 2011 to 2015 Bangladesh faced significant political unrest [19] while from 2019 to 2020 education got hampered due to the pandemic rise. While in these moments, the expenditure on education should have been the most so that students could have continued their studies sitting at home and taking technological benefits.

Moreover, thousands of requests come from the corner of the country to get the schools repaired from calamitic damages but often the requests get ignored. Due to a lack of transparency, huge chunks of funds allocated for the educational sector get wasted.

Children are seen studying under trees. If technology in education becomes affordable, and at best if provided by the government, then it will lead to a positive impact on education quality and distress.

Trained teachers

The most basic weakness in Bangladesh's education system is the quality of teachers. Every year more than thousands of teachers are recruited but sent straight to the classrooms. They are not facilitated with any sort of training to get adapted to the students, teaching abilities, and classroom environments. Although Bangladesh has different training opportunities for teachers, they claim it after they assure themselves of the teaching opportunities. This usually doesn't happen in most other countries. This also causes a major reason why students focus on guidebooks rather than classroom studies. As the teachers often fail to make the students understand why they are learning the contents due to the absence of practical usage. This also happens because teachers receive the teaching materials later and often lose interest in using them.

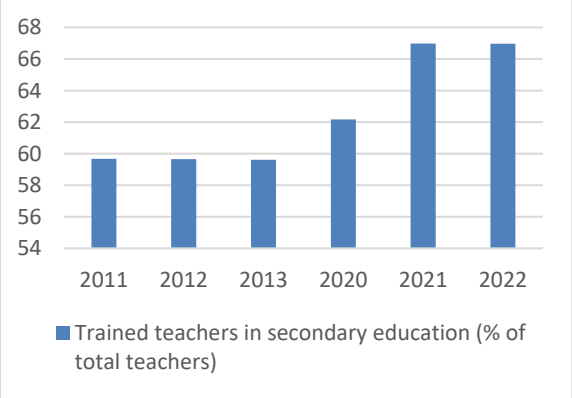

Figure 3.: Trained teachers in secondary education (% of total teachers) [20]

Note: Bangladesh did not meet the criteria for inclusion in the 2014 issue of Education under Attack, so no comparisons or identification of trends was possible.

Secondary school is the most important as it introduces students to advanced and specific subjects and develops social and communication skills. The graph illustrates the percentage of teachers trained in secondary education as a percentage of total teachers at Bangladesh's secondary level. Analyzing the data it is seen that a major portion of the data is missing from 2014 to 2019. It can be assumed that Bangladesh went through black phases during those days for political unrest and the pandemic which may disrupt teachers' training. Moreover, most teachers were trained in 2017 when Bangladesh was having a stable phase [21]. Therefore, pervasive computing technology can be used to train the teacher without any hamper even when the country is facing a major breakdown.

School enrollment, secondary (gross)

Secondary education in Bangladesh ensures that the citizens receive extended and consolidated primary education. In the secondary education curriculum, the education board of Bangladesh ensured that the students receive knowledge on various subjects and develop potential abilities that prepare skilled manpower for the country's economic development. The curriculum also ensures that education makes the students good and responsible citizens. Reforms come every year with the development of the era. The number of students enrolled in school regardless of age is seen to identify whether the adverse situation impacted education enrollment over the chronic years or not.

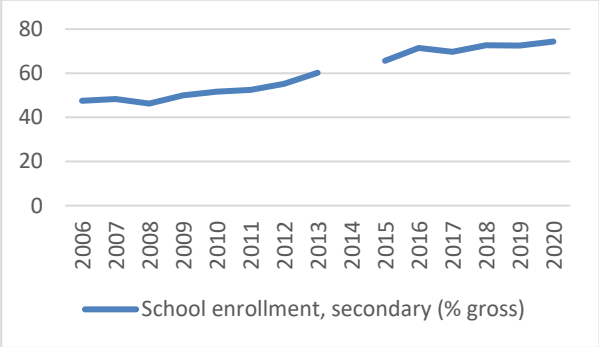

Figure 4.: School enrollment, secondary (gross) [22]

The above graph illustrates that as with previous data on trained teachers, the website lacks data from 2014 on the issue of Education under Attack. It is seen that irrespective of the situation, school enrollment gradually increased over the years. That means people in Bangladesh are aware of educating their children. But just enrollment does not fulfill the education condition. Education should not be hampered. It is mentionable that, the government of Bangladesh is ensuring free, equitable, and quality primary and secondary education for both males and females leading to a relative and effective learning outcome. In Bangladesh, the citizens have the right to be educated by the constitution. The major hindrance to citizens getting education even after getting enrolled is inadequate infrastructural developments, pandemics, natural disasters, and political or rural attacks. This makes education less worthwhile even

though the number of enrollments is gradually increasing over the years.

Conclusion on reasons to ensure pervasive computing to support education.

From the above discussion, it is seen that Bangladesh's education is greatly hampered for various causes. Every year the children continue their education even in between natural calamities, political and rural unrest, and infrastructural developmental barriers. Yet, two major cases were highlighted to grab an understanding to the point that greatly hampered education in 2014 and 2019. After revising the cases, trends from 20016 to 2020 data were analyzed. Four graphical data concluded that the number of internet users is increasing gradually over years. But unfortunately, the government expenditure on education has decreased. Again, an unstable environment has hampered teachers training over the major years when education faced distress for shutdowns. Irrespective of all these conditions, the school enrollment rate has not decreased but increased which means the citizens are aware of the importance of being educated. Therefore, if the citizens get proper support, they can be skillful. And during stressful situations, the best support can be provided by affordable pervasive computing technologies.

B) Ways pervasive computing can support education during adverse situations in Bangladesh.

Quality education can be provided only then when the systems delivering education are well built. Educational reforms can be successful when the policy design is good enough to tackle stressful situations, has strong political commitments, and capacity to implement effectively. This is quite challenging and requires struggle and dedication to make efficient use of the resource. Increased education or spending does not mean improved learning or human capital. To overcome the challenges, it is important to work at all levels of the system.

Bangladesh is already advanced in keeping a hand with international organizations like UNICEF, JAAGO, World Vision, etc. to meet sustainable development goals and education program policies. Interestingly, the graduates and students often educate the street children for free at their best level. The country needs to attract the best experts in implementing evident-based and country-specific programs. The regional offices need to monitor and support learning tools. The teachers need to be trained and prepared so that they can lead schools. But all above these, what happens when the situations are adverse and hamper education to a great extent? The problem usually arises for issues like unrest, disasters, pandemic, construction, and many more. The students sit idle at home and hardly reach their basic levels as a major portion of the classes are missed. It is also difficult to cover the missed education in the following years.

Providing videos on YouTube, or websites are not an actual process as students often get demotivated to watch the videos, feel idle, and have less concentration than in real-life classes that can be more enjoyable. During Chronic situations like political unrest when education is greatly hampered as people feared from getting out of their houses, and disasters when people need to change their locations for shelter, even in cases like the pandemic or when the roads and school ways are under construction for months that causes difficulties for students to visit educational premises, pervasive computing acted as a great solution.

There is multiple software that provide education over the internet, like Zoom meeting, Google Classrooms, and many more. The main thing is access to the internet and the ability to have access to these internets. Unlike earlier days, the internet is not as expensive, but it is not yet affordable by all. People who live in remote areas do not even have internet access, let alone a device to access the internet. The government of Bangladesh is providing technological devices free for educational purposes, but this is not sufficient. Then what can be the solution?

To ensure education with no barriers educators can start using microchips. These microchips will provide knowledge anytime anyplace so that the smallest bit of education does not get missed. The microchips can also be used in making an interdisciplinary analysis. The wireless sensor networks in microchips will allow real-time data for research and avail the data through internet gateways. Also, wearable computing will make IoT into reality by selling them in embedded chips. These microchips can communicate with the brain and outside the body as well.

C) Ideas of using microchips as a pervasive computing technology

The idea of pervasive computing includes Shimeng Yu's [23] interdisciplinary education opportunity through his neuro-inspired computing research. As a part of finding the best solution to continue education during adverse situations, the

research came through that the neuro-inspired computing technology can emerge as a nano-device that creates self-learning microchips. From Yu's innovation, we developed a concept that the microchips boast the capacity to learn in real-time, adapt to the environment and once embedded in a smart device like a mobile or laptop can have a wide range of data that consists of the annual lessons.

So, the thing works in a way like the microchips supporting education will be provided during the beginning of the schooling session. For underprivileged students, microchips are provided free of cost. And for general people, this must be at affordable costs. As the government of Bangladesh is providing free books, and laptops such as Doel, the better provision will be microchips. Each microchip will hold a user identification and passwords. Once the microchip is embedded in the device, the students can see the lessons of the year at a time. But each activity will be time-bound, and activity based following the curriculum. For example, students learning numerically in the first chapter can have access to summation in the second chapter once they successfully pass the activities in the first chapter. Teachers of each class will have access to the microchip. They regularly conduct the class at fixed times where they can see the student's attendance as well. Once the adverse situation is overcome, the teachers may check the activities done through their devices and judge the skill gained by respective students. By this, the student's education will not be hampered, and skills can be judged after the situation normalizes.

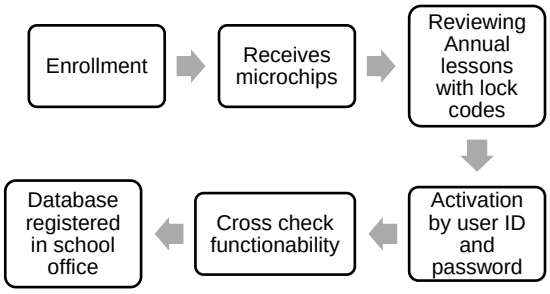

Figure 5: The idea of initiating microchip

The second step when the student uses the microchip during adverse situations is also depicted below:

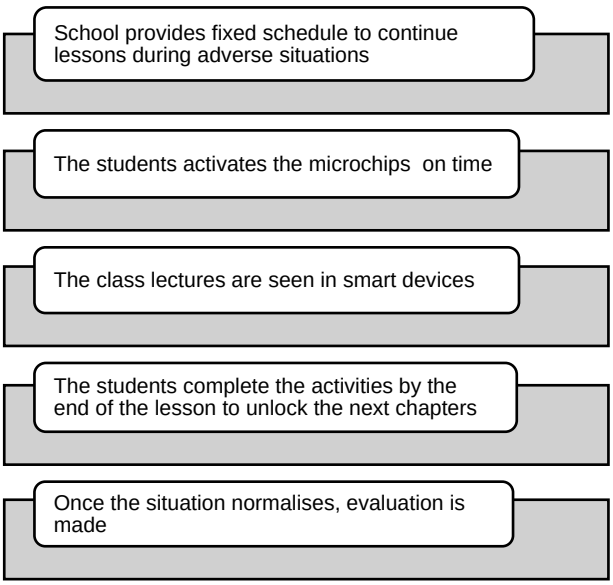

Figure 6: Demonstration of the usage of microchips in adverse situations

As soon as the students receive the pervasive technology, education goes on a natural flow. The students visit the school on a regular schedule. But in case any adverse situation attacks then the chip is activated. For example, in natural disasters like Cyclone or flood when the school premises get damaged. Will the students in certain areas stop their education until the school infrastructure is repaired? Let alone in 2022 heavy flood in the north-eastern regions of Bangladesh has taken a heavy toll on education in 5000 schools of 18 districts. In such cases, the trained teachers can continue to educate the children using pervasive technology. They can continue the classes by providing fixed schedules for all the students to attend classes at a time. Point to be noted that, during adverse situations often the network towers are also damaged. This means, the students, even though having technological devices, can hardly be connected to the internet. So, connecting microchips can be the most feasible solution. By connecting the microchip to the desired and active devices students can view the lectures of that time they are missing according to their syllabus. Within the given schedule the students complete the activities and unlock the next lesson. When the situation normalizes, the teachers can check on the activities and determine the student's level of understanding. For any difficulty they observe in any specific chapter, the teacher can review it. This will save time and ensure that education goes perfectly hand in hand.

D) Reasons microchips can be one of the best pervasive computing technologies for education.

The question may arise how this is different from the usual internet-based system like Google Classrooms and others in trend. First, as this is not internet-based, students can have access to class lecturers from their storage devices and understand the lectures. Second, the activity is locked based which means, students cannot have access to the next lectures until they finish the first one. This means the students are bound to complete all the sessions. Third, the teachers are also aware of whether the students have gained the knowledge properly by checking their class activities and students can also clear their confusion by interacting after using the microchip. Fourthly, as the internet has a monthly cost associated that is not affordable by most citizens who are underprivileged, providing affordable microchips and supporting devices selectively can be a greater solution as they get a whole year of lessons at a time. As the previous statics demonstrated, citizens of Bangladesh are already aware of being educated, so if they are facilitated with proper support then the education can be continued without any barriers even in wars, disasters, pandemics, or more. Moreover, this also opportunism the females, who get fewer opportunities to study, or the age group who wants to study but couldn't for any situation. They can get educated from home if they get the option. But this doesn't mean the necessity to visit school premises will end. As school develops more skills like socializing, and communicating, and have many more skills to be gained that cannot be learned through devices. Finally, this is different from general videos or online classes as it is activity based, so it will demand full concentration and understanding from the students. If the activities are designed to be more fun, and analytical based then students' boredom will also be overcome.

The pandemic spiked the demand for an economy that is hungry for chips. Video conferencing, online classes, and remote work have increased the demand for more cloud power and devices. All this demands more and more microchips. The people have adjusted to the new technological evolution that increased the semiconductor industry's capability to produce cheap and powerful microchips. If microchips are used as mentioned idea, it will presentably reduce the disparity in education. Mentionable that, UNICEF reported that more than 770 million children aren't going to school and 24 million dropped out of the pandemic. For most, in-person learning is a dream, and the only way they can learn is by learning virtually or not learning. The ed tech can reduce this disparity and the bottleneck is availing the microchips at the cheapest possible rate.

VI. RECOMMENDATION

Many developed countries have adopted education using the Internet of Things (IoT), Artificial Intelligence (AI), and many more, but the least developed countries are yet to follow these tactics when they are much in need. So, some recommendations include,

First, the government needs to ensure cheap technology so everyone can be facilitated. The underprivileged must receive the device free of cost.

Second, the technology can come in the form of a microchip that holds the whole year's lesson and is provided to students at the year's beginning.

Third, each chapter must be unlocked after ensuring the previous chapter is studied. Activity will be included so that students' ability in that specific lesson can be judged. These activities are reviewed by the teachers and after proper evaluation, the students get the lock codes to the next chapter. The activity must be designed in a way that takes students' attention. By this, even in crisis moments, students' education is ensured. Moreover, their skills in those chapters are evaluated. This also judges students' knowledge acquisition.

VII. CONCLUSION

Education is strongly linked to later jobs, income, and health. If education is ignored, then the setbacks now will last a lifetime. With the developments of the world, education is facing adverse situations whether it's for war or any chronic diseases. To ensure a knowledgeable and healthy nation, education should not be hampered. Otherwise, the learning crisis that the world is facing will extend. The paper, therefore, highlights different cases when education hampered in Bangladesh in 2014 for political turmoil, and in 2019-20 of the pandemics. The paper also highlights the general causes that daily hampers education like chronic disease, village fights, natural calamities, and infrastructural developmental works. Based on these cases, the data trend from 2006 to 2014 is studied to know how education was hampered in adverse situations. It is seen that the enrollment rate and teachers training in 2014 and 2019 were insignificant. Also, to understand the scope of pervasive computing in Bangladesh the number of internet users is studied and found that a very significant number of people in Bangladesh are using technological devices. Viewing the school enrollment rate, it can be analyzed that the people in Bangladesh are aware of educating themselves, and the main thing they need is proper support. The data also overviews government expenses over time, where it is seen that the expenses gradually decrease. So, a special focus must be made to increase the investments in education. An educated nation means a healthy nation.

After studying the reasons to use pervasive computing, the paper suggested using affordable microchips as a medium of pervasive computing so that education does not get hampered in an adverse situation. The paper also highlights different previous studies where the usage of the microchip in the education system was emphasized. There may be a lot of slackening effects on the ed-tech product innovations. But as the world develops, the least developed countries mostly need technologies to alleviate poverty and non-hampered education. This is only possible when pervasive computing technology is used for educating the nation as a part of the education system in an integrated way.

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