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Foreword

I am happy to note that the Ministry of Housing and Urban Affairs and the National Institute of Urban Affairs (NIUA) is releasing a set of best practices in the book 'SAAR: A compendium of 75 Smart Cities Projects'. It is pleasing to know that this compendium has been compiled by our partners in academia, with students and professors from 15 premier institutes contributing innovative studies on urban policies and reforms in 47 Indian cities.

Under the leadership of the Hon'ble Prime Minister Shri Narendra Modi ji, urban development has assumed central importance in India's growth story. It is seen as a means to accelerate economic growth even as it aims to provide urban dwellers with a better quality of life. Initiatives such as the Smart Cities Mission were launched with the purpose of unlocking the potential of urban areas through technology and citizen-friendly reforms.

R&D institutions, led by the enterprising zeal of their young researchers, are playing a crucial role in supporting urban development programmes. As India looks to become a developed nation by 2047, it is important to encourage research, and promote a scientific and technological bent-of-mind among the younger generations towards the field of urban development.

This compendium is a stellar example of the potential of the 'demographic dividend' that lies within India. More than 65% of the country's population is younger than 35 years of age today. It is imperative that we provide opportunities to our youth to engage with development processes and conceptualise solutions to India's emergent problems.

I congratulate the Smart Cities Mission, NIUA, and above all, the students and professors who prepared this compendium. It will surely be a useful addition to the growing discourse on urban development in India.

New Delhi
07 March 2023

(Hardeep S Puri)

A15

Smart Classes Project, Agra

Name of the project: *Nagar Nigam Inter College School and Girls High School*
Location: *Tajganj, Agra, Uttar Pradesh*
Year of Project Implementation: *2019*
Sector: *Smart classes*
SDG: *SDG 4 - Quality Education*
Project Cost: *Rs 0.61 crore (Rs 3 crore - entire upgradation and civil work)*

Institute: *IIT-Roorkee*
Advisors: *Faculty Coordinator: Dr. Arindam Biswas, Mentor: Ms. Nikita Ranjan*
Students: *Ms. Shipra Verma and Ms. Kritika Sharma*

Keywords: *Smart Education, Smart Schools, Technology Enabled Learning*

Abstract:

The Smart City Mission in Agra is based on the renewal, retrofitting and extension of the city. There are several flagship programs under the mission and one of them is the 'Smart Classes'. Agra Smart City Ltd (ASCL) is trying to improve 'how education is delivered in the municipal schools. It has implemented smart classes in two municipal schools in the ABD area (Area Based Development). The idea was to implement smart classes in all the classrooms which led to significant improvement in the quality of education. The project was completed in February 2019, and it is being used extensively by students and teachers. The research evaluated the condition, work and improvements in the system with the help of secondary and primary studies.

The primary study was done for both the schools. Students, teachers as well as officials were asked questions. This helped to know the ground reality and how the project was working. Since the project started in 2019, and the pandemic hit immediately after, it was hard to evaluate the work. It started working properly only by the end of 2020, so evaluations are based on this short experience. Indeed, it is a great initiative, as the number of admissions has increased drastically and student engagement has also improved.

Case Study: **15**

1. Introduction

Agra Smart City:
Agra is located in Uttar Pradesh, a Northern state of India. Agra city is administered by the Agra Municipal Corporation. According to provisional reports of Census of India, the population of Agra in 2011 was 1,585,704, with 845,902 males and 739,802 females. The population of Agra Metropolitan Region which includes the Municipal Corporation is 1,760,285 of which 939,875 are males and 820,410 are females (Census of India, 2011).

In September 2016, during the third round of the Smart Cities challenge, Agra was selected to be developed as a Smart City. Agra Smart City Limited (ASCL), a Special Purpose Vehicle (SPV), was established to spearhead the Smart City project. The Companies Act is used to establish the SPV that carries out development projects at the municipal level. The Divisional Commissioner led the team to plan, approve, implement, manage, monitor and evaluate the Smart City related projects. Agra's Smart City projects comprise core redevelopment initiatives for Rs 2,133 crore. The proposed ABD is spread across 2,250 acres. The project will include areas around the Taj Mahal, Agra Fort and other important corridors of heritage and tourism in the city.

The area based development is an urban renovation, retrofitting and extension program started under the Smart City initiative by the Government of India in 2015. The goal was to enhance city infrastructure and improve the quality of life of the citizens. Each Smart City is expected to establish an ABD plan to revitalise an existing location through retrofitting, redevelopment and reconstruction. The pan-city plan would use smart city-wide infrastructure technologies to improve the infrastructure and services for all inhabitants.

The vision for Agra Smart City has been founded on the goals of its citizens as well as on an analysis of the city's strengths, weaknesses, opportunities and threats. Tourist-friendly, "memorable," "liveable," "culturally vibrant," "economically dynamic," "preserve and cherish history," "urban mobility," and "sustainable" were among the topics suggested by the citizens.

The vision statement for Agra Smart City is, "The City of Taj – where history is preserved, the environment is pristine, infrastructure is world-class and opportunities are plenty – a safe place to live, a great place to tour". The following flagship projects have been proposed under the Smart City initiative, which need to be implemented in the city.

- Integrated Command & Control Centre
- Micro-Skill Development Centre
- Automated Self-Cleaning Toilets
- Smart Health Centre
- Smart Classes

This research paper focuses on the study of **Smart Classes**.

1.1 Topic and Context

What is a Smart Class?
Smart classes are a way to teach students by using upcoming technology. This will enhance the teaching and learning experience for both teachers and students. Since it is a new skill-set, teachers need to learn it before teaching the students. It has been proved that visuals, videos and audios increase the memory of our brain, as we tend to remember the things we see and experience rather than just reading and writing. Smart classes are a way forward to enhance learning and creative skills, especially in children. The pandemic has also forced colleges and schools to adopt smart classes.

As technology and smartphones reach all household levels, it is observed that even children are getting used to operating smartphones. They spend more time on devices and are able to get a firm grasp on them. Smart classes are a way to teach them in a more creative and fun way. Smart classes are transforming their way of learning, making it easy and fun rather than it being a cumbersome task. According to the Indian education sector, only 10 per cent out of 1.3 million private schools have adopted the multimedia classroom teaching (Anu, 2021). This method engages students with the help of videos and animations. It also helps teachers to quickly evaluate the students' work and performance by making use of innovative technical instruments.

Traditional Classes vs Smart Classes
For traditional classes, teachers prepared lectures using textbooks and a chalkboard, while the students scribbled notes and essential points on paper. Students were occasionally brought outdoors for hands-on demonstrations and a better understanding of the subject. Students had to wait until the following day to raise questions in class if they had any uncertainties. Additionally, students used their textbooks and reference books from the school library to create notes. Furthermore, all examinations and evaluations were carried out manually.

Smart classrooms, like other types of classes, strive for high-quality learning, but the methods are different. Smart classrooms are equipped with computers, laptops, high-speed internet, LEDs, projectors, eBooks,

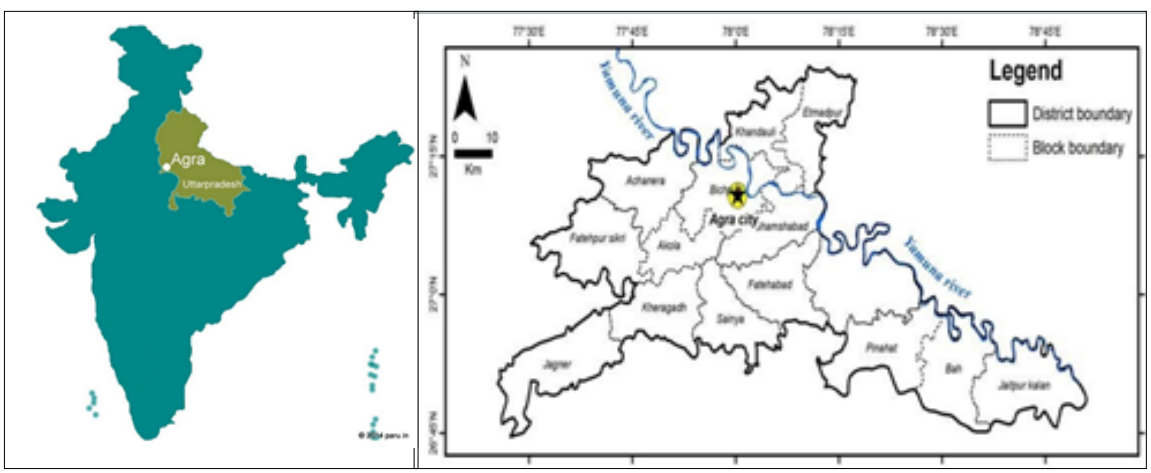

Figure 1.Location of Agra in India
Source: (Singh et al., 2020)

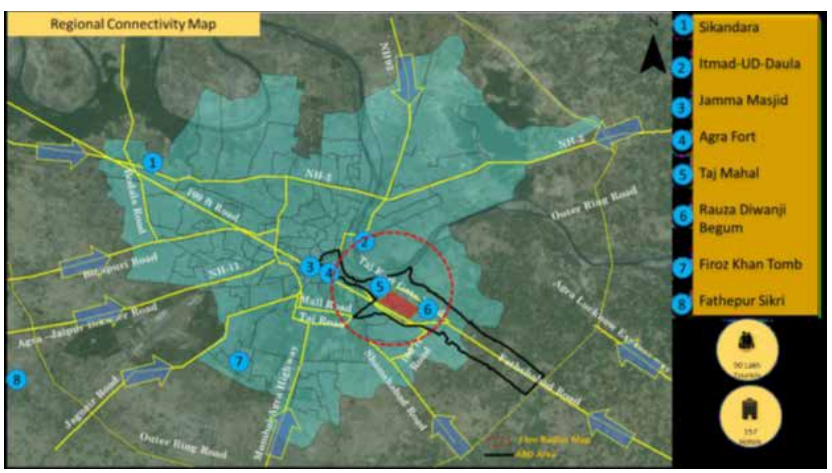

Figure 2. ABD Area and Regional connectivity map,
Source: Agra Revised Detail Project Report Estimated 2019

and other ready-to-use technology. Students participate actively in the classes, thanks to the audio and video lectures from their teachers and from professionals around the world. Teachers have direct access to their doubts, if they have any. Students can also communicate with their professors after the lectures and vice versa.

- Access to Online Information:
  Students and teachers have access to an online resource database and a variety of tools to help them study and teach more effectively. They gain access to online study materials such as movies, lectures, documentaries, PDF files and photographs, among other things.

- Accessibility:
  In smart classrooms, a high-speed internet connection allows students and teachers to rapidly access information from numerous educational sources, as needed.

- Connectivity:
  Smart classes are generally available in all locations for cooperation and motivation of distance learning. The goal of using technological tools to improve regional connectivity is to promote total engagement by students in learning from diverse places.

- Easy Access to Online Resources:
  It is simple for teachers to use computers to demonstrate concepts to pupils because smart courses are linked to internet and computers. One can extract and download study material using the internet. eBooks and other online learning resources are also readily available to students. In addition, the online mode of teaching makes exchanging of material easier for both teachers and students.

- Increased Productivity:
  In lesson plans with smart courses, students become more engaged and develop a higher level of interest. They have access to a variety of learning and practice resources to help them achieve improved results. It also promotes effective student-teacher interaction, allowing them to work together to achieve even better academic results.

- Interactive Learning Experiences:
  Teachers use projectors, presentations, movies and graphics to provide interactive sessions. This leads to growth of the student-teacher relationship, as the visualisation of lesson plans increases the students' curiosity and engagement, resulting in more inquiries and interactions between the two parties.

1.2 Scope of Research

a. The study is based on one of the flagship programs of Agra Smart City i.e., Smart Classes.
b. The first section of the study is based on secondary data and literature review and the second section is based on primary surveys.

1.3 Significance of the project

The project aims to provide quality education and change the way education is delivered in schools. Before this project was implemented, municipal schools were looked down upon because of poor infrastructure and unavailability of proper resources for education. This project not only provided better education opportunities to students but also changed the way municipal schools were looked upon.

The arrival of modern equipment for teaching and the infrastructure development attracted many parents and students to the municipal schools, rather than going to private schools, which were unaffordable for the lower-income groups. Now, people from the lower and middle-income groups are encouraged to send their kids to the municipal schools, since these schools match their level of performance with the private schools.

1.4 Aim and Objectives

The aim of the research was to analyse the quality of education provided in municipal schools by implementing smart classes (Nagar Nigam Boys Inter College and Nagar Nigam Girls School in Tajganj (ABD area).

The objectives of the project were:

a. To evaluate how quality of education has improved by smart classes.
b. To evaluate the problems faced in implementing the smart classes.
c. To evaluate how Covid-19 has changed the way in which smart classes work and the difficulties faced during the pandemic .

2. Contextual Background

- Secondary study
- Design and proposal analysis
- Primary study and users' reviews
- Difficulties faced during Covid-19

2.1 Conceptual Framework:

Table 1 shows the detailed research framework. The research was designed in a categorised manner since every objective of the research required a different set of data and analysis. Accordingly, for each objective relevant methodology was devised to achieve the objectives in a systematic and concise manner. The methodology can be observed in the below table:

Table-1 Evolution Framework
Source: Authors

Sl. No.	Objectives	Evolution Framework
1.	To evaluate how the quality of education has improved by this initiative of Smart Classes.	a) Assessment of grades
		b) Performance assessment before and after the smart classes, involvement of students in class
		c) Change in the way students work (Classwork, homework, assignments)
		d) Increase in the number of admissions after implementation of smart classes

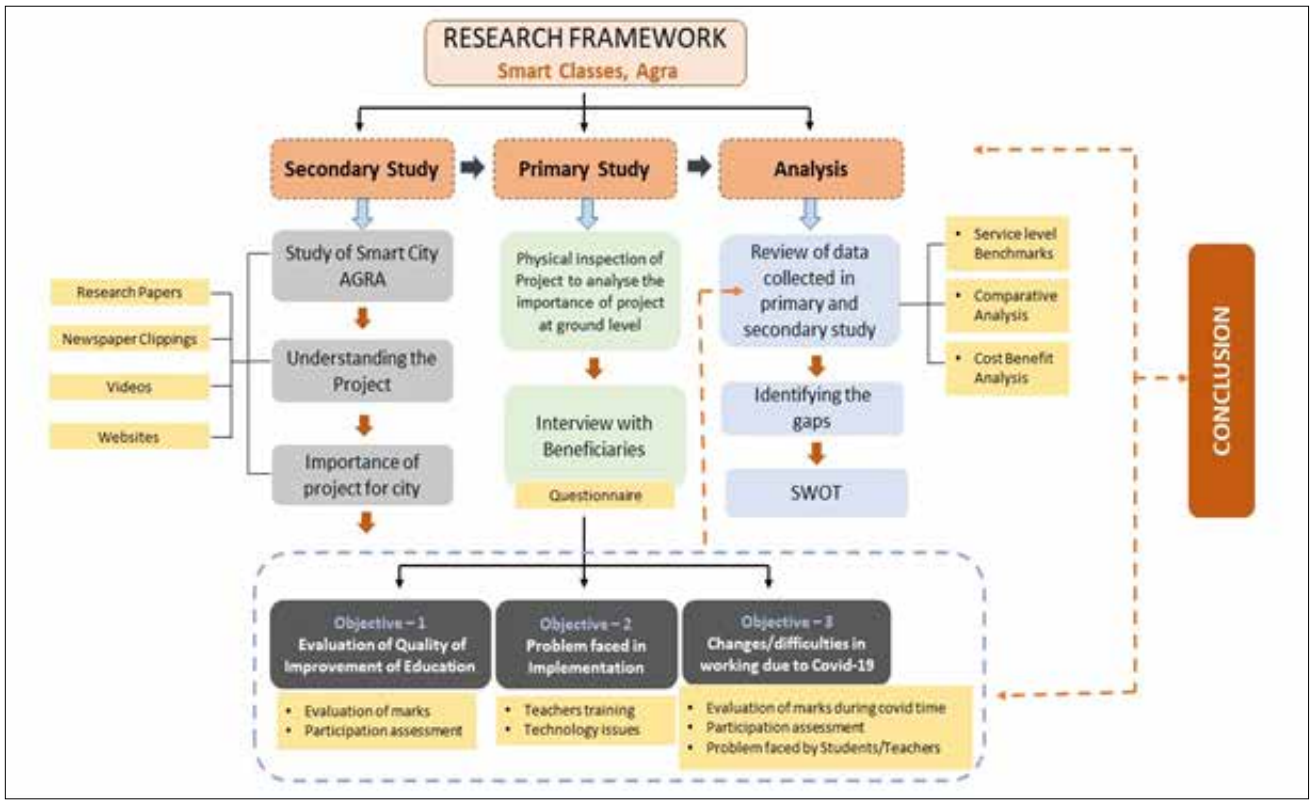

Figure 3: Research Framework, Source: Authors

Sl. No.	Objectives	Evolution Framework
2.	To evaluate the problems faced in implementing the Smart Classes.	a) Teacher's training: To be equipped with tools on how the smart classes work
		b) Assessment of the gadgets and equipment used to conduct smart classes
		c) Internet and technical issues
		d) Issues related to the availability of study material for smart classes e) Inquire about maintenance problems, annual repair/service data regarding infrastructure
3.	To evaluate how Covid-19 changed the scenario of how Smart Classes work and the difficulties faced during Covid-19.	a) Number of admissions after Covid-19
		b) Assessment of grades
		c) Involvements of students in class. Is there an internet issue, class timings and any adverse effect on the children's health?

2.2 Key features of the project

Up-gradation of two municipal schools was implemented under the Smart City Project - Agra Nagar Nigam Inter College & Girls High School, in Tajganj.

Smart components

a. Interactive multimedia content
b. Projection equipment
c. Online support for students and teachers
d. Capacity building of teachers

The features of smart classrooms include the following:

a. Interactive Multimedia Content: The NCERT aligned interactive multimedia content for classes I to X which includes English, Mathematics, Science and Social Science. This comprised a variety of animation and video-based modules as well as simulation-based interactive virtual experiments which help students to grasp concepts by bringing real-world examples into the classroom.

b. Projection Equipment: With a compact, simple, yet powerful gadget like a projector, classrooms are dedicated to simplifying the way technology is used. It can be fully embraced by teachers when attached to any projection system. Teachers who were hesitant of using technology in the classroom will also quickly adapt to the digital teaching and learning environment.

c. Online support for students and teachers: This creates a shared learning ecosystem for students and teachers on a single platform with an account, username and password for everyone involved. Students can utilise this platform to engage with one another and share ideas. All information, including manuals, write-ups and videos are hosted on this platform. Students and teachers can communicate with professionals in their fields using the ask-an-expert option.

d. Capacity building for teachers: Practical demonstrations in constructive approaches such as inquiry, activity and project-based learning has been included in the teacher's capacity building exercise. This training will build on the instructors' existing skill-sets, ensuring that any transition is managed gently, seamlessly and successfully. Each semester, the teacher's capacity building is conducted within two 5-day workshops through online sessions and handholding.

Figure-4: Existing Plan of Inter College School
Source: Agra Revised Detail Project Report Estimated 2019

Figure-5: Entry Gate of the Nagar NigamInter College School,
Source: Authors

Figure- 6: Tajgang area just outside the Nagar Nigam Inter College School.
Source: Authors

Basic requirements of municipal schools:

Modifications to the physical environment:
While the school's infrastructure is adequate, certain minor improvements are required:

a. A water filtration plant is required for clean drinking water
b. Improvement of the school's toilets and sanitation
c. The school's environment can be improved by using BaLA (Building as a Learning Aid) by painting on the walls of classrooms and hallways to explain the curriculum themes and creating a vibrant learning environment in the process. Children are continually receptive to different sensory experiences and subconsciously assimilate inputs from their surroundings. The school environment can be improved to create learning opportunities at every turn of the building's contours to realise this potential. It can be carried out directly by the Municipal Corporation, with contractors providing need-based assistance in identifying areas for improvement and sharing designs where appropriate.

Computer Lab:
Technology-based learning solutions create a virtual learning environment that makes education more engaging and enjoyable. The IT-based education solution programme establishes an atmosphere in which learning and evaluation are enjoyable and the learning possibilities are equal for children in rural and urban areas.

"Equal knowledge for everybody" and "Assessment is Fun." To promote student retention and instructor effectiveness, it is advocated that technology classrooms be gradually integrated into the school. Under Ed-Value, the following aspects will be addressed:

a. ***Computers:*** A modern digital lab will be set-up for the school, complete with computers, scanners, printers and other essential hardware/software to teach students and instructors about technology-enabled learning as well as IT-skills and training.
b. ***Projection equipment:*** Use an interactive projection device like the one shown below, as well as a high-quality projection system.
c. ***Extended Curriculum:*** The school's existing computer lab can be reinforced by adding a relevant computer education programme, ensuring that students are well-prepared for the difficulties of the modern workplace and are able to benefit from the global digital revolution. Computer labs can be utilised for computer-assisted study of academic courses as well as train students on information technology. The curriculum structure focuses on the student's overall development and preparation as a global citizen. It includes WHO-recommended Life Skills, the 4Cs of 21st Century Skills (creativity, critical thinking, teamwork and communication), and information, media and technology skills (Agra Smart City Limited, 2019).

Locations of municipal schools:
Two locations were identified in the ABD area.

Table-2: Location of the schools

S. No.	Location Name	Proposal
1.	Agra Nagar Nigam Inter College School, Tajganj, Agra	Retrofitting and Equipment
2.	Girls High School, Tajganj, Agra	Retrofitting and Equipment

Agra Nagar Nigam Inter College School, Tajganj

The Nagar Nigam Inter College School is in the precinct of the Taj Mahal, at a distance of 600-m from it.

The medium of study is Hindi and classes are from 6th to 12th standard, with three or more sections for each class. Higher classes (9th to 12th) have four or more sections. It is an only boy's school till the 10th standard and offers co-education in 11th and 12th standards. The total number of students is approximately 900. Children from Tajgang as well as the neighbouring areas come here to study. Although the condition of the Nagar Nigam Inter

College School is better than the Nagar Nigam Girls School as some of the rooms are not in working condition, e.g., the physics lab, chemistry lab and library. The number of equipment in the labs is also insufficient and not all of them are working. The technical glitches and lack of proper internet connection hinder the functioning of the classes.

Smart components used in the classrooms:
a. Interactive Multimedia Content
b. Projection Equipment
c. Miyawaki Forest

Girls High School, Tajgang:

This school lies in the vicinity of the Taj Mahal in the Tajganj area (ABD area), within a 500-m radius. The school is affiliated with the UP Board and the medium of teaching is Hindi. It has classes from 6th to 10th standards. Every class is divided into two or three sections with around 60 students per section. There are around 600 students studying in this school. Presently, there are 10 teachers. There were only 400 students in the school before the smart classes project was implemented. Post smart classes, an increase in the students' admission has been observed.

Smart Classes Equipment:
a. Projector
b. Cameras
c. Speakers
d. White Boards
e. Monitors
f. Pen drives (Syllabus is stored in it)
g. Mouse
h. Smart Projector Pens

2.2.1 Challenges in the project

Unlike traditional classrooms, smart classrooms integrate education and technology with the internet, giving students access to web-based online learning through smart devices and provides teachers with innovative teaching tools to teach virtually through interactive programs.

Figure-7: Existing Plan for Girls High School
Source: Agra Revised Detail Project Report Estimated 2019

Figure- 4: Students studying in the smart classroom
Source: Authors

Figure- 9:Open Air Theatre
Source: Authors

However, there are significant logistical obstacles that come with implementing such programs, particularly in municipal schools, which frequently lack the necessary physical infrastructure. Some of these are:

a. The implementation of such schemes is frequently hampered by the construction of existing buildings.
b. Seepage and dampness through the roof.

2.2.2 Risks involved in the project

The deployment of smart classrooms in municipal schools carries the following risks:

a. Effective maintenance of smart boards and projectors
b. Teachers' and students' ability to adapt to the changing technology and learning environment. The program's effectiveness is dependent on the teachers' and students' willingness to accept the smart learning methodology.

2.2.3 Features and Benefits

Due to the execution of this project, admissions to these schools have increased by at least 6% in comparison to prior years. The ongoing teacher training programs have been organised to familiarise teachers with smart classes. So far, smart courses have been introduced in 23 classrooms across the two Nagar Nigam schools.

The evolution of a school can be viewed in terms of four factors that influence the quality of education:

a. Cognitive Environment: For pervasive learning
b. Social Environment: For a healthy school culture
c. Administrative Environment: For good professional connections
d. Physical Environment: For a pleasant learning environment

When all four factors of creating an active learning environment are addressed, schools become more effective. Some NGOs or contractors intend to collaborate with the Municipal Corporation of Agra's Value initiative to improve the active environment in these schools. To improve the quality of education, a holistic quality improvement programme has been conceived to create an active environment in a school, with emphasis on enhancing learning outcomes. The school will be outfitted with a mix of teaching and learning resources, technology infrastructure, administrative assistance, infrastructural enhancements and necessary capacity building efforts for teachers and the school administration as part of the programme. To ensure that the programme is effective, active project management and monitoring and evaluation is done.

2.3 Key findings from the interviews, surveys and primary data collection:

Smart classes in the municipal schools in Tajganj were developed as a tool to improve the teaching and learning experience of teachers and students. The redevelopment of the two municipal schools will benefit the population of the area because Tajganj is home to

Figure- 10: White board placed on top of the existing black board
Source: Authors

Figure-11 E-Toilet near the open air theatre
Source: Authors

Figure- 12: School Ground
Source: Author

Figure- 13: Books storage in Library at the Girls High School
Source: Authors

Figure- 14: Library Reading Area
Source: Authors

Figure- 16: Music Room in Girls High School
Source: Authors

Figure- 16: Music Room in Girls High School
Source: Authors

low-income families who cannot afford to send their children to private schools. The data from the two municipal schools was gathered through questionnaire interviews with six students and four teachers from the Girls High School and seven students and five teachers from the Nagar Nigam Inter College School, along with physical observations of both the schools. The students selected for the survey were from various classes and the teachers taught a variety of subjects.

Key findings from teachers/vice-principal:
Primary data was gathered from a total of nine teachers. The questions were asked in accordance with the objectives. Initially, they were given a five-day training to help them grasp how smart classes work, but the teachers believe that this is insufficient. Before Covid-19, they had received little training. Now, they want a thorough revision of what they had learned prior to the pandemic. Educators believe that the deployment of smart classes and general reconstruction has resulted in a 10-12 per cent boost in the overall grades of the students. Participation of students has also increased. Now, they ask more questions and participate in discussions. They work more efficiently in class, on assignments and at home. There has also been an increase in the number of admissions.

Teachers claim that there are enough gadgets in the classroom, but not all of them are functioning. The school lacks an efficient internet connectivity due to the availability of only one modem which is unable to cover the entire school. Some teachers also expressed dissatisfaction with the white boards being hung on top of the black boards. They require a black board for in-class activities and work. The syllabus is provided to them on pen drives, which can stop working or become corrupted by viruses. They don't have any technical support to overcome such malfunctions.

During the Covid-19 pandemic, teachers were not able to take classes. Although some teachers tried to teach through the online medium, but no support was provided to them by the school authorities. Even students were not able to attend the classes because of lack of gadgets in their homes. So, overall smart classes did not help much during the pandemic.

Key findings from students:
Overall, all the students interviewed were satisfied with their smart classes and enjoyed them. They were unfamiliar with this new form of teaching by using audio visual experiences, but they were eager to learn as much as they could. They also mentioned that their overall understanding has improved and that they are now better able to comprehend mathematics and science subjects. Although all classrooms have been converted to smart classes, not all subjects are taught using smart classes.

When asked about the pandemic, they said they had a lot of difficulties during lockdowns and that many of their friends dropped out of school due to financial difficulties. Also, due to lack of infrastructure and devices at home, many students were unable to participate in the online classes. Covid-19 created a void in their education.

3. Discussion and Conclusion

This entire project is a good initiative to improve education. It involved improving the skills of teachers and students. In the initial stage of the programme, the teachers were trained on how to teach in the smart classes and how to use technology to enhance the study experience for the children.

During the initial stage of the project, several challenges were experienced. During the project implementation, proximity to the Taj Mahal resulted in prolonged processes for the necessary construction approvals. During the operational phase, students and teachers experienced technical issues with the computers and other electronic devices. They needed dedicated services of technicians to resolve the equipment glitches.

They are also promoting new initiatives such as Miyawaki plantation, e-Toilet, rainwater harvesting and open gyms which are hardly seen in other schools. The officials claim that such initiatives will educate the students on environmental sustainability. Improvement in the quality of education and admission of new students are clearly evident in both the schools. The smart features being used in the school teaching pedagogy is attracting parents and students. Private schools are known for extensive use of smart classes. Using smart classes in public schools may improve the performance and perception of municipal and public schools. The improvement of the environment of the two public schools impacted their admission volume which increased significantly, beyond their capacity. However, smart classes were not helpful during the pandemic largely due to technical issues.

3.1 Implications (the impact assessment framework to be included here)

An impact assessment framework has been devised to derive the implications of the project.

Inputs:
This includes the allocated financial resources for the development of smart classes. The total project cost is Rs 0.61 crore.

Process:
The process includes surveying the existing condition of the municipal schools. The desired investments in infrastructure, equipment, capacity building and expenses for teachers' training and administration were made as per the budget. All processes were carried out by the Agra Smart City Limited.

Output:
The resultant output was the renovation of both the municipal schools which were equipped with all the necessary facilities to assist in the teaching and learning process.

Outcomes:
There is a 4-6% increase in student admissions. Students are enjoying the smart classes more than the traditional classes.

Impact:
There is an increase in the level of understanding of the students along with making teachers and students technically literate. The municipal schools are gaining in infrastructure as compared with the private schools.

3.2 Limitations of the research

The limitations of the research are listed below:

- Only a limited number of students and teachers were interviewed due to time constraints
- Data on the long-term impact of the project was unavailable

3.3 Key lessons learnt

The key lesson learnt from the secondary study:

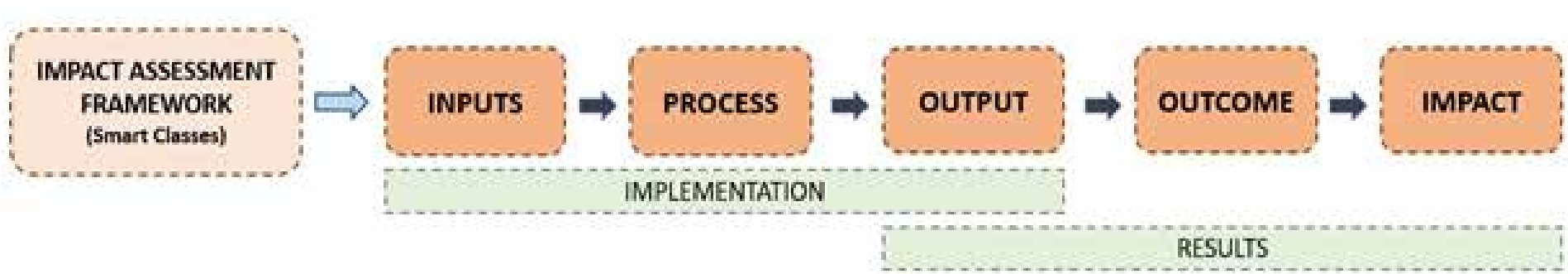

Figure- 16: Impact assessment framework. Source: Authors

Secondary data is very essential for urban planning and research, particularly in times of Covid-19. A careful analysis of the secondary literature is important to get a first-hand observation of the subject and arrive at a preliminary framework for the research. Well-documented literature enhances the overall experience.

The key lesson learnt from the primary study:

While preparing questionnaires, the details of the potential respondents including their age group, background etc was considered. One prominent learning is to have a mix of objective and descriptive questions to comprehend the stories associated with each question.

One of the primary skills is to be patient during surveys, particularly during filling the questionnaires. This enhances the quality of research.

3.4 Recommendations

Firstly, smart classes are a medium to enhance the quality of education, but it is not the only mode of study. The presence of a teacher and the inputs from a teacher cannot be replaced by smart classes. However, smart classes have a significant impact in making classes and teaching more interesting and interactive.

It is observed from the primary study that the online smart classes were not helpful for the students during Covid-19. One of the limitations was the lack of facilities and proper personal equipment for the students.

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