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Examining Learner Agency in Online Teaching

G. S. Prakasha[1,*], H. Hasham Sarah[2], K. Y. Hemalathaa[3]

[1]School of Education, CHRIST (Deemed to be University), Bangalore, 560029, India
[2]Al Muntazir Islamic Seminary High School, Dar es Salaam, Tanzania
[3]Pathways International School, Gurgaon, Haryana, India

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Abstract Ever since the Gurukul system of education in India, the school education followed a Sage on stage approach. Over the past few decades, teachers have started to believe that a guide on the side approach is critical for deeper learning to take place among students. With the technological advancement in the field of education and evolving pedagogies, parents have also started to believe that learners must bear the responsibility of their learning under the supervision of teachers. Learner agency has different connotative meanings in different countries. In the present study, learner agency refers to a student's ability to play an active role in their education [1]. Outburst of COVID-19 in India has led to the introduction of online teaching in most of the urban schools. Routine lifestyles of student's have been changed due to lock down of the schools. Lockdown of schools has brought about changes in the Learner agency. Therefore, the present study is to examine the learner agency in an online teaching environment and to describe the changes in the learner agency due to the online learning environment. The study employed a qualitative research method to examine the changes in learner agency. A semi structured interview was conducted to a group of upper primary school students who were learning via online teaching. Study was able to examine the changes in learner agency due to online teaching and learning. The results of the study will help school teachers to understand the changes in learner agency in an online learning environment and how to support learner agency or to become co-agent? In an online teaching learning environment.

Keywords Online Teaching, Learner Agency, Upper Primary

1. Introduction

Learner agency has gained popularity over the last two decades among educational researchers. However, there is a paucity of research related to learner agency in distance learning [2]. Learner agency is now becoming a default expectation of learners [3]. Learner agency is perceived as learners' latent potential for self-directed engagement [4]. Agency consists of both the ability and the preparedness of a learner to take action. Learners can be agentic which is evident in learning sites either from their interest in learning or from their commitment demonstrated towards an assignment or a task [5]. Learner agency "is the process in which students intentionally and somewhat proactively try to personalize and otherwise enrich both what is to be learned and the conditions and circumstances under which it is to be learned" [6]. The study assumes that the students these days have the ability to make choices and act on those choices to make a difference in their life [7]. The learner is actively involved in the learning process and is equally involved in interacting with the environment [8]. The learner needs to have the ability to act intentionally in order to be an agent during the learning process. The fundamental characteristics of agency are to empower individuals to play a part in their self-development, adaptation, and self-renewal in time of change [9]. As learners take an active role in seeking and internalizing their knowledge in the online environment, it has a significant effect on his or her academic achievement [10]. Learners make conscious choices and play an active role during the period of one's own learning. The Learner agency shifts the ownership of learning from teachers to learners providing opportunity to have an understanding to be a part of the learning

design and to take responsible actions to intervene in the learning process.

In the last two decades numerous researchers have conducted studies related to learner agency. The scope of those studies ranges from conceptual understanding to measurement of learner agency. However, there is a paucity of research on examining learner agency especially in online context and distance learning [2]. Learner agency has been researched with different perspectives such as Sociological perspectives, Psychological perspective, and technological perspectives. Learner agency is a dynamic process embedded with changes in time and context [11]. Research experiments in various disciplines such as educational psychology, cognitive psychology, complexity theory, socioemotional learning, and Educational technology determine the significance of giving learners' opportunities to drive their learning and growth both individually and collectively [12].

Pajares in his study quotes that unless people believe that their actions can produce the outcomes they desire, they have little incentive to act or to persevere in the face of difficulties [13]. Bandura in his study brings out that the core features of agency enable individuals to play a part in their self-development, adaptation, and self-renewal with changing times [9]. Van Lier (2008) argues that the agency is a core concept in constructing the identity of an individual. Nagaoka in his study mentions that agency depends upon intentionality and forethought to derive a course of action and adjust course as needed to reflect one's identity, competencies, knowledge and skills, mindsets, and values [14]. Vaughn in his study defines agency as a student's desire, ability and power to determine their own course of action [15].

Agency, however, is not a fixed quality, and it is not something that students do or do not have [16]. Nagaoka and colleagues, in their report on a developmental framework for young adult success, stated that a person may demonstrate solid agency in one setting and yet be unable to transfer such robust agency to another setting. Rather, agency can vary from context to context, and from time to time: agency is something that people do in social practice. This nature of agency can help teachers understand how a student may practice agency in one situation but not in another [17]. As Gresalfi and others pointed out [18]: A person's agency in a brief episode of interaction is, in part, whether he or she initiates an idea, agrees with, elaborates on, questions, or disagrees with what someone else initiated, or refrains from responding. It also depends on whether her or his action is accepted, elaborated, questioned, challenged, or ignored. Early adolescence is a period where swift growth takes place [19] the idea of learner agency is associated with cognitive and intellectual development in young adolescents. This is a period where learners are acquiring the capacities for metacognition and abstract thought [20]. They are also developing acquaintance towards the subjects that are relevant and are meaningful to them. Reeve and Tseng (2011) studied agency or agentic engagement, as a form of student engagement. The behavioural, emotional, cognitive, and agentic aspects of engagement were studied in detail. Monica et al (2018) found out the conditions for cooperating and dialogue through the utilization of technology in online education [21]. Muyinda et al (2019) found that open distance learning is a way to transform higher education [22]. Hussin et al (2019) presented an exhaustive review on classification of students' interaction in an online learning environment and came out with the strategies to enhance online interaction [23]. Prakasha (2020) highlighted the need for training in information and communication competency involving online teaching and how it contributes to student learning [24].

The COVID-19 outbreak has encouraged teachers across the country to use a wide range of technological tools available for real time chat style or synchronous computer mediated communication [25]. This study aims at examining the learner agency in online teaching which not only guides the teachers but also the learners to navigate through the uncertainties faced, to contribute and become active agents. Nagaoka and colleagues, in their report on a developmental framework for young adult success, stated that a person may demonstrate solid agency in one setting and yet be unable to transfer such a robust agency to another setting. Rather, agency can vary from context to context, and from time to time: agency is something that people do in social practice. This nature of agency can help teachers understand how a student may practice agency in one situation but not in another [17]. Therefore, the present study is to examine the learner agency in an online teaching environment and to describe the deviances from the usual learner agency behavior due to the online learning environment.

2. Methods

When we looked at the reviews of related literature for the present study, we found that there are quite a few studies which talk about the conceptual framework of the learner agency and its field of application. Few other studies are ethnographic studies related to learner agency. Thematic and survey studies related to learner agency were also found to be conducted in different parts of the world. The present study was aiming at finding the differences in the learner agency of upper primary school children from normal face to face learning environment to online teaching learning environment and due to the COVID-19 lockdown situations study resorted to qualitative methods. The study conducted a semi-structured interview to the students of upper primary school children of age ranging from 10 to 13 years (see

Table 1). The research method followed for the present study is outlined in the figure 1 given below.

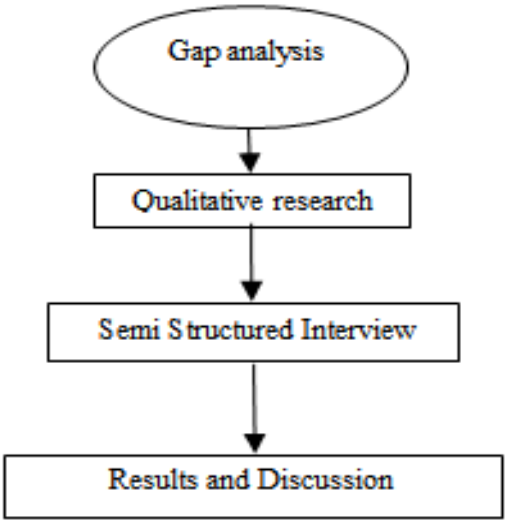

Figure 1. Showing the study design outline

2.1. Scope and Limitations of the Study

The present study is conducted to examine the changes in learner agency in an online learning environment and describes the changes in learner agency due to the online learning environment. The study followed a qualitative research design. The data are collected from a semi structured interview only. The sample of the study is restricted to the students studying in Upper primary schools in the age range of 11 to 13 years only.

2.2. Sample of the Study

Students of the age group between 11 to 13 years were considered for the sample of the study. These students are attending the upper primary school and now due to lockdown are attending online classes conducted by the schools. 10 students were selected at the convenience of the researchers and were subjected to semi structured interviews each at a time [26]. Students in their later childhood are growing mentally, physically, socially, and emotionally at a faster pace. Students in their later childhood love to be led and are enthusiastic about taking independent responsibilities of their education. Hence the later childhood stage has been selected for the study as a sample. This is the age where the learner agency is in the formation stage and taking shape in an individual's life.

2.3. Semi Structured Interview

The researchers constructed a semi structured interview questionnaire for the present study (See Table 1). These questions are open ended and cover almost all the components of learner agency. Open ended questions are followed by a spontaneously devised follow up questions to elicit more information from the participants. As the participants are of the age group 10 to 13, their honest responses can be obtained in one shot and they may vary in their response if we make more than one attempt to conduct an interview. We were a team of three to conduct interviews at different times and places. Hence researchers have resorted to semi structured interviews for the present study [27]. The one-on-one interview has been conducted to all the participants of the selected sample. As it is a semi structured interview, the questionnaire questions were asked in a random order and depending on the responses of each participant on spot, spontaneous follow up questions were asked to the interviewee. The responses obtained were diligently recorded and that formed the data of the study.

2.4. Validity of the Questionnaire

The constructed semi structured questionnaire has been subjected to face validity and content validity by the researchers and researchers arrived at a consensus while retaining each item of the questionnaire. Then the constructed semi structured questionnaire has been validated by a panel of experts who worked in the area of learner agency and their feedback was incorporated in the final form of the questionnaire. The items of the semi structured questionnaire are also in concurrence with the works of Zeiser et al [10] and Grip tape youth leadership board.

Table 1. Showing the Semi structured interview questionnaire

Semi structured interview questionnaire on Learner agency in online teaching-learning Instructions: Following are the questions related to learner agency in online teaching mode. You are expected to recall your role as a learner during online teaching mode and respond to the following statements and any follow up questions thereafter each question. Your identity will be kept confidential. Your responses will be recorded and will be used for the purpose of research and publication only.	
Sl. No	Semi structured interview items
1	Have you been punctual to all your online classes?
2	Are you completing all the asynchronous assignments given to you on time?
3	Were you multitasking during your online classes? Explain
4	Were you able to collaborate with your peers on learning using phone calls/ WhatsApp/ SMS? Explain
5	Do you think you can achieve goals that are important to you? Explain
6	Were you distracted by complex assignments and its completion on time? Explain
7	Do you sometimes log in to online class and not present in front of the computer? Explain
8	Do you seek help while answering your online tests from parents or the internet? Elaborate
9	Do you hesitate to clarify doubts in an online class? Elaborate
10	As you have a few hours of online classes in a day? What do you do in the remaining time? Explain
11	If you were asked a question in online class for which you don't know the answer, what is your response? Elaborate
12	Do you think online learning is good enough for your future life? Explain
13	Do you think the online teaching, learning materials, and assessments are meaningful to your learning? Explain
14	Do you think you miss your teachers recognizing your work in online mode? Explain

3. Results and Discussion

The results and discussion of the present study have been explained in two sections. Section 1 describes the interview output and Section 2 describes the deviance from the learner agency with a word cloud.

Section 1

The data collected out of semi-structured interviews regarding the learner agency in online teaching-learning from upper primary school children have been interpreted. There were 14 open ended questions in the semi structured interview questionnaire. The questions were pertaining to different aspects of learner agency such as punctuality of students, assignments or tasks shared by teacher's, collaboration, classroom interaction and communication among students and teachers, time management and task assigned, integrity of the students while taking online assignments, understanding student daily routine, their responses to questions posted online, their personal understanding, view point towards online teaching, and students voice towards the learning environments. The responses obtained for each of these questions from the respondents were thoroughly analysed and are interpreted in the following paragraphs;

(i) Have you been punctual to all your online classes?

Majority of the students interviewed stated they were punctual to all the online classes that were scheduled. As the timetable was shared well in advance and they were familiar with the subject classes that were scheduled on a daily basis. Initially, some of the students did face issues of logging in late or re-login into their classes which was highly due to internet issues but as the day's progressed they were able to ensure that these glitches were well taken care of. However, some of the students did mention that they were getting up late, and as they needed not to go to school physically, they were logging in with a casual approach and used to have their morning breakfast simultaneously.

(ii) Are you completing all the asynchronous assignments given to you on time?

Most of the students felt they were able to work on the individual tasks or assignments that were assigned to them by teachers. Due to the lockdown, they in general felt that they had enough time to post the class hours to work on the assignments. Many of them did mention that it was difficult for them to prioritize on days when more than three subjects assignments had to be submitted at the same time. Some of the students did mention that they did not receive feedback to some of the assignments that were submitted, they did mention receiving constructive feedback on time would help them as they work on similar assignments or prepare for their final examination. Some students did not turn in the assignment and were pretending to be offline due to internet issues when the teacher was verifying their assignment submissions.

(iii) Were you multitasking during your online classes? Explain

Some students felt it was challenging for them to listen and understand the concept taught by the teacher in a

particular subject and simultaneously making notes was a challenging task. Some students felt it was easier for them to make notes in subjects like English or Social Sciences but felt challenging when it came to solving mathematical problems. Some students felt, the online classes demanded more attention while the teacher was explaining the concept and hence giving not scope for multitasking. It was also noticed that many students who skipped their breakfast as they woke up late or skipped lunch as they had to switch from one class to another did utilize the time during the session to have their breakfast or lunch. It requires teachers' attention to understand the amount of break time to be given between classes, asynchronous activities, a number of classes per day a student can attend in a virtual setting. There is also a definite need for schools to understand how they wish to balance the synchronous and asynchronous learning environments. Some of the students did have multiple Gadgets with them like personal computers, smart phones, and a tablet computer, and have logged in using a tablet to attend the class but were playing using the smartphone and use smartphone to check for answers to the questions posed during the class.

(iv) Were you able to collaborate with your peers on learning using phone calls/ WhatsApp/ SMS? Explain

All the students interviewed felt that peer to peer collaboration was the most challenging task as they felt some of the group members were not responding while trying to communicate through email, Phone call/ WhatsApp/SMS. This resulted in either student working on the whole assignment on his/her own or looking for other peers who were willing to cooperate and work with them. They felt looking for a common slot where everyone in a team was available for collaboration apart from the class time was a challenging task. Most of the students felt the lack of collaboration among the peers resulted in submission of poor assignments and consumed more time among students who were initiating to reach out to their peers. Some students shared that, their friends were ignoring the phone calls and messages and not ready to share the responsibility because in a virtual situation nothing much a teacher can do about it. This is a clear breach of learner agency behavior.

(v) Do you think you can achieve goals that are important to you? Explain

Most of the students who were interviewed had a mixed opinion on the achievement of their goal. Some felt they performed academically well in some subjects and were unable to achieve the same in other subjects. Few also felt they would have performed well if they were attending schools and classes in a normal environment and they did prefer learning face to face. Few students did share their dissatisfaction on how they were unable to participate in any extra - curricular activities and hence unable to achieve the goals they had set for themselves. They felt the online teaching environment was mostly academic oriented and had less when it came to extracurricular activities. They felt they are helpless in an online environment to steer their life goals.

(vi) Were you distracted by complex assignments and its completion on time? Explain

Students had a mixed opinion on this question. Most of the students expressed that on a regular basis there were at least three subject assignment submissions all going at the same day which made it challenging for them to give enough time to complete the assignment. Few students felt that whenever they were stuck or were unable to proceed with the assignment, they approached the teacher via email or WhatsApp at times to clarify the doubts and to proceed with the assignment this did delay the process of completing the assignment when their query replies were delayed. They felt difficult to sit back to work on the assignment and it distracted their concentration and zeal to continue to work on the assignment. Some of the students did mention that although the assignments were submitted. They did not receive any constructive feedback which did demotivate them to quite an extent. As it is all happening virtually, some students also took the help of their parents and others in the family. Some even tried to reach out to their classmates to copy their ideas and submitted their friends' work as theirs. Some of them also mentioned that schools must take care of the amount of assignment workload regularly to avoid over burdening.

(vii) Do you sometimes log in to online class and not present in front of the computer? Explain

Students gave varied encounters to the above question. Most of the students mentioned that they were present during all the class except for the time while they had to use the restroom, or fill their water bottle, or bring materials necessary for the online class. These were some of the excuses they expressed which led them to not to be present in front of the computer. Some students mentioned that on days where they woke up late and could not have breakfast, they did use the class time to have their breakfast, but they used to be present in the online class. Many students did mention that there were essential agreements set by some of the teachers during online classes like keeping the video turned on, Audio to be turned on whenever necessary and so on, and probing questions to students at times. This did encourage students to not just stay in front of the computer but be fully present during the class. But, in classes where there were no essential agreements set by the teacher, it was observed that some of the students did not respond to a question asked or did not turn on their audio or video which also specifies that they were not paying as much attention required by the online classes.

(viii) Do you seek help while answering your online tests from parents or the internet? Elaborate

All the students said they did not seek help while working on an online test. Upon questioning on formative quizzes and tests, there were mixed responses. Some said

no, some said they google immediately and answer, some sought answers from brothers and sisters in the family. Some of them also pretended to be disconnected or not hearing the questions on routine class quizzes. Upon questioning why they took help? They said, they are not seriously getting ready for formative tests as it is a virtual mode there is nothing much teachers can do in this mode to punish them.

(ix) Do you hesitate to clarify doubts in an online class? Elaborate

Most of the students felt comfortable asking questions to teachers personally either by sending an email or by sending a quick question on WhatsApp so on. However, some of the students did make use of the CHATBOX option available on the online platform to post a question or used to raise the hand option for the teacher to respond and if missed by the teacher even there they would reach out to the teacher directly to receive a response and to clarify the doubt. One or two students did mention that they were reluctant to ask questions during the online class as they felt they would be noticed and few others felt lackadaisical.

(x) As you have a few hours of online classes in a day? What do you do in the remaining time? Explain

Most students said they engage in doing home assignments, but upon further questioning some of them said, they are eagerly waiting for the class to get over so that they can play computer games, watch television, browse on social networking sites like Instagram, Facebook etc., and play in the neighborhood.

(xi) If you were asked a question in online class for which you don't know the answer, what is your response? Elaborate

Almost 50% of the students mentioned that they would respond honestly that they did not know the answer to the question. But few others said that they use google quickly to find a relevant answer to the question posted by the teacher and give answers based on what they read up on google. But upon further asking why you never knew the answer? They said, they did not even reflect on why they couldn't answer? Have they understood the concepts? Was it taught? They blindly felt guilty for not answering the teachers' questions.

(xii) Do you think online learning is good enough for your future life? Explain

Students had different perspectives while they answered this question. Few students felt that they were enjoying online classes as they are able to get more time to study and for test preparation. Some felt online learning to be beneficial but did not prefer it on a long run. They did observe, some of the peers not responding to their teachers most of the time during the online class which at times used to be difficult for teachers also that they could not have control on certain students in a virtual environment or to even know if they were involved in the learning process itself. Few students felt online classes lack social interaction either between peer to peer or peers to teacher. Online learning is very individualistic and would benefit the students who are self-driven and ready to take responsibility or ownership of their learning. At the same time, it would be difficult for students with less attention span to concentrate or to utilise online learning in a more constructive manner. Few students were very vocal about how some of the peers in the class would initially misuse the online platform by muting the teacher, or removing a student from a class and so on. However, as the school made an informed decision to move from Zoom to Microsoft Teams, many of these aspects were taken care of. Syllabus completion in the given period of time was also one of the concerns that students think it will be challenging to completely lecture or teach those subjects. However, they also understand that online class is not just about lecture methods. This also opens more questions directing teachers to explore pedagogies that are more relevant to an online learning environment and mindfully include students' voice and choice in the learning process.

(xiii) Do you think the online teaching, learning materials, and assessments are meaningful to your learning? Explain

Some students mentioned that, when application type questions were asked during class quizzes, they felt it was not being taught. Certain videos shown during classes are not exactly as per the concept to be learned. In some of the test evaluations, the teacher could not give feedback to all the mistakes, some mistakes mentioned were not very satisfying to the student due to virtual set up. This has led students to think, online learning is little vague when compared with face to face teaching-learning.

(xiv) Do you think you miss your teachers recognizing your work in online mode? Explain

Almost all the students said that teachers cannot reach out to all students in a class as it will take more time. Same students are active in most of the classes and passive students remain passive mostly in classes and teachers and friends are not sure what is going on with them? Some of the students did mention that it was difficult for them to learn some of the subjects completely online like Sciences (Physics, Chemistry, & Biology) especially while working on experiments they did mention that they were missing the firsthand experience associated with learning these subjects. They had a vague understanding of these skills and were unsure of using them in real life situations.

Section 2: Deviance from learner agency

From the above discussions following deviances from learner agency were observed by the researcher. Students are found to be not punctual to their classes and also onto their daily routines. They took online teaching as temporary status and were casual in their approach to learning and working on their assignment. They were

found multitasking during the online classes. They were not satisfied with the teacher feedback and thereby felt their work was unnoticed and lost faith in online teaching and learning. They even took advantage of virtual setup to find answers to the formative questions by other means. They also found themselves hesitant to ask questions as they were not confident of receiving a satisfactory answer to their questions. They were playful and mischievous in some classes. They were playing and spent time aimlessly during their free time. The above discussion clearly indicates the deviance from the learner agency. The researcher has come up with a word cloud on deviance from learner agency and is shown in figure 2.

Figure 2. Showing the word cloud on deviance from learner agency

Examining learner agency in online teaching-learning environment has helped to bring out the following suggestions to the stakeholders; conducting an orientation to students by sharing the essential classroom agreements, their roles and responsibilities, steps for setting a home work station, expectations during the online (synchronous classes), and a time table for asynchronous activities for out of class hours are vital needs that have to be paid attention by the teachers and school heads. Having parents in confidence, schools may also inform parents on the basic requirements, support, and monitoring which will be required to ensure students make the most out of it. Teachers and parents must act as co-agents to support teaching and learning of their wards.

4. Conclusions

The present study was able to identify the changes in the learner agency of upper primary school children of the age ranging from 10 to 13 years due to the online teaching-learning environment. The changes observed can be detrimental to the individual in building up a successful career and to lead a quality life. Therefore, there is a need for teachers that have co-agent to provide positive intervention when they identify unhealthy changes of learner agency because of the online teaching-learning environment. Teachers as co-agent may help children in understanding their roles and responsibilities as learner agents and also guide parents if possible to provide timely advice to their wards in minding their responsibilities. As later childhood is a part of the learner agency formation stage, there is a need for the stakeholders to understand the context of learner agency and to act rationally and responsibly towards it.

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Conflict of Interest Statement

All the three authors of the present study declare that there is no conflict of interest pertaining to this study and have arrived at a consensus to decide on the corresponding author.

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M. Anand, G. Devi, S. Gokul Raghavendra, et al.

A Critical Study on Acetylene as an Alternative Fuel For Transportation

M. Anand[1], G. Devi[2], S. Gokul Raghavendra[3], G. S. Prakasha[4], T. Lakshmanan[5, a)]

[1]*Department of Chemistry, Kingston Engineering College, Vellore, India*
[2]*R.M.K. College of Engineering and Technology,Puduvoyal, Thiruvallur, India*
[3]*Bharath Institute of Higher Education and Research, Chennai, India*
[4]*Christ University, Bangalore, Karnataka, India*
[5]*S.R.M Institute of Science and Technology, Kattankulathur, Chennai, India*

[a)] Corresponding author: lakshmat@srmist.edu.in

Abstract. With the traditional power sector hindered by fuel shortage and climate changes, the promotion of green energy becomes the most prioritized objective of the government. The ministry's move becomes significant because conversion to cleaner energy sources is the best way to minimize global warming and to reenergize the global economy. Among the available alternative gaseous fuels, acetylene caters to these needs because of its property similarities with hydrogen. In this research, the suitability of acetylene as an engine fuel is analyzed. Also, the production methods, combustion properties, abnormal combustion, and safety issues were discussed. This review paper describes about the various possible modes of fuel induction techniques to be adopted. The research establishes the utility of acetylene as a commercial fuel for internal combustion engines in the future years by the adoption of suitable methodologies.

Keywords: Acetylene, Alternative Fuel, Transportation.

INTRODUCTION

Many hydro-carbons and other fuels were used in I.C. engines right from their inception, which resulted in the quest for alternate fuels. Even though petrol and diesel fuels are on the front-line of usage, laboratory and field investigations are still undertaken on alternate fuels to find their suitability for identifying the exhaustion of prime hydro-carbons. Alternative fuels that are used include natural gas, Liquefied Petroleum Gas (LPG), biofuels, transesterified vegetable oils, and alcohols. Some fuels which cannot be directly used as neat fuels are used as additives (Ex: dimethyl ether (DME), alcohols, and oxygenates). Recently, ethanol (produced from sugarcane) has been accepted and permitted in India to blend with petrol up to 5-10% in an effort to reduce the import bill and to promote the life extension of petroleum products globally. A novel attempt which analyses the suitability of welding gas (acetylene) as fuel for I.C. engines is outlined in this paper.

Acetylene production: Acetylene was discovered in 1836 in England by E.Davy. Acetylene is a colorless, combustible gas with a distinctive odor. Acetylene is a hydro-carbon consisting of two carbon atoms and two hydrogen atoms. Its chemical symbol is C_2H_2. For commercial purposes, acetylene can be made from several different raw materials depending on the process used. Acetylene is primarily produced by any of the following methods:

1. By the reaction of water with calcium carbide
2. By passing hydro-carbon with an electric arc.
3. Partial combustion of methane with air /oxygen.

Hydrolysis of calcium carbide to acetylene: The simplest process the hydrolysis of calcium carbide, which produces acetylene gas and calcium carbonate slurry, called hydrated lime. The chemical reaction is written as

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$$CaC_2 + 2\,H_2O \rightarrow C_2H_2 + Ca(OH)_2. \quad \text{(Eq 1)}$$

The reaction of calcium carbide with water is significantly exothermic. In commercial practice, the heat of reaction is controlled by the generators designed. This is done to facilitate the acetylene-generating rate of 0.03 m^3/h using 0.5 kg carbide and 3.8 liters of water. Generators have various components, which include water containing reactor chamber, carbide hopper, acetylene water scrubber, and gas storage tank. The generators are protected with pressure relief valve and flash arrestors to prevent the acetylene deflagration.

Acetylene from hydro-carbon: Acetylene is produced from hydro-carbon decomposition at elevated temperatures greater than 1000 °C, using various energy sources with a short residence time (0.01–0.001 sec). The cracked gas containing acetylene is quickly cooled to 550 K to prevent decomposition to carbon, hydrogen, and tar.

$$C_nH_{2n} \longrightarrow 2C_2H_2 + (1+2/nH_2) \quad \text{(Eq 2)}$$

Partial combustion process: The partial combustion method generally involves preheating a natural gas or methane/Naphtha feedstock with a limited amount of oxygen (HC/O_2) to about 500–650 °C. The burner design is of critical importance for preventing back-firing. Combustion must be rapid and uniform, followed by the rapid quenching of the reactor gases. In new processes, coal injected into hydrogen plasma can be converted to yield acetylene. Acetylene tends to become combustible when it is subjected to heat, compression, induction to a liquid state, or when combined with air. Hence, extraordinary safety measures need to be implemented when acetylene is produced and handled. Acetylene can be procured from different raw materials based on various processes. For the purpose of separation, acetylene is liquefied in different solvents like acetone, cooled methanol, ammonia in the anhydrous state, and water. Research on the acetylene engine has come a long way in the past several decades, although some NOx emissions are formed. Hilden et al. [1] carried out a test in a single-cylinder S.I engine with constant speed, constant airflow. The research was focused on the control of the dangerous NO_x emissions by systematic analysis. The important parameters taken into consideration were the compression and similarity ratios. The work also established the better working of the engine under acetylene. Unfortunately, increased combustibility ranges and volatile disintegration inhibited the utility of acetylene in this research. Another research that witnessed the development and modification of a normal CI engine into an acetylene-diesel compatible engine was done by Lakshmanan et al. Here; acetylene was fed in the intake manifold for different gas flow rates of a CI engine. The induction of acetylene resulted in a mildly reduced thermal efficiency of 26.9% when compared with 27.9% under diesel usage. Again, the NO_x emission was also high when acetylene was used. A maximum emission rate of 46% of NO_x emission was seen proportionate to the acetylene flow rate, which was 389 g/h at specified loads. Due to the elevated ignition speed, the pressure also increased. In spite of the increased NO_x, a reduction of the other emissions like CO, HC, and CO_2 was witnessed. The undesired element of back-fire also happened when the dual-fuel engine was run at unusual circumstances. Some analytical research was undertaken by Lakshmanan et al. [3] with different flow volumes of acetylene in a dual-fuel engine. The research established a reduction in the BTH when acetylene was fed in fastidious quantities along with the main fuel. The crest cylinder pressure (Pmax) and NOx emissions were seen under the noteworthy elevation due to the increased flame rate in the acetylene -diesel form of process. The emissions, which included the HC, CO, and smoke, were reduced remarkably. The research undertaken by Lakshmanan et al. [4] on the use of acetylene in the dual-fuel form in CI engine accounted for a marginal elevation in the smoke emission. But HC, NOx, and CO emissions were decreased due to the depleted working of the engine. Also, the brake thermal efficiency was very much comparable with the neat diesel. This established the secure efficacy of acetylene using the port injection method. Lakshmanan [6] also established that the NOx was minimized, and the smoke levels were slightly increased when the EGR technique was used to induce acetylene at the manifold. Pritinika Behera et al. [7] investigated and analyzed the experimental results of a diesel-acetylene dual-fuel operation. A diminishment of ignition delay, small drain vapor temperature, and elevation in pressure was seen at complete load states. Srivastava et al. [8] analyzed the induction of acetylene under different compression ratios. In the dual-fuel operation, the average thermal discharge and optimal pressure were more. But, the exhaust gases (C.O., H.C., and smoke) were reduced when compared to the neat diesel utility.

Sudeesh et al. [9] and Swami Nathan et al. [10] undertook experimental researches using a HCCI engine under acetylene utility. They surmised a development in BTE up to 10%. The NOx and smoke were less under both modalities. Choudhary et al. [11] analyzed a diesel engine consisting of various CR trials (18, 18.5, 19, and 19.5). The research established that the BTH was more for 19.49 CR. An elevation in P_{max} and a reduction in EGT was seen when the CR was increased. Brusca et al. [12] analyzed the theoretical and experimental parameters of the I.C. engine running on alcohol and acetylene. They proposed the possibility of the attainment of acceptable performance of the engine with low pollutants. While compared to the gasoline engine, there was a decrease in performance by

25%. Mahla et al. [13] studied the performance of the engine fueled with DEE and acetylene. Tests were conducted with various blends of DEE with diesel as ignition source (DEE10, DEE20, and DEE30) and fixed volumes of acetylene. An increase in brake thermal efficiency and a decrease in smoke and exhaust gas temperature were observed when operated under dual fuel mode. Choudhary et al. [14]undertook research that involved systematic acetylene variation (5lpm, 6lpm, 7lpm, and 8lpm). Based on the engine output parameters (emissions, performance, and combustion), 7lpm of induction was optimized as the best flow rate. Basha et al. [15] and Sharma et al. [16] had done extensive research and suggested acetylene as one of the best alternative fuel whose performance characteristics are closer to the diesel engine without any loss of brake thermal efficiency. From the literature review, it is clear that the acetylene utility involves undesirable parameters inhibiting the performance of the CI engine. With the usage of advanced fuel delivery systems, premature ignition can be controlled. However, much research needs to be conducted before an acetylene based system could be made practical, cheap, fossil-based, greenhouse impact reduced.

Properties of Acetylene: The physical and chemical properties of acetylene with respect to engine combustion properties are given.

Molecular Structure: Acetylene is an open-chain unsaturated hydrocarbon containing one C–C triple bond, with a bond length of 1.20 °A with a strength of 837 kJ /kg.

Density: For acetylene, the specific temperature and pressure influence the confinement of the molecular structure. Acetylene has a density of 1.092 kg/m^3 at normal temperatures and pressures. Acetylene fuelled engines are not inhibited with engine derating because the density of acetylene is slightly lighter than air. This is the unique property of acetylene with respect to hydrogen (0.08 kg/m^3). This property reduces the power output of the hydrogen-fuelled engines as more quantity of gas has to be inducted to produce the same power output as the designed engine.

Specific Volume: The characteristic is the exact opposite of density, which identifies the quantity per unit mass. The specific volume of acetylene gas is 0.981 m_3/kg at normal temperature and pressure.

Range of Flammability: The flammability range is a significant fuel property. This characteristic is an assessment of the extent of the air/fuel ratio available for the engine working. Acetylene has an enormous flammability range when contrasted with conventional fuels. It can be operated on a lean assortment, which contributes to the economy. The fuel temperature can be reduced by using ultra-lean assortments, minimizing the extent of NOx. The flammability extent of acetylene is 2.5–80 %. It is volatile at normal conditions. The flammability range is 0.3 to 9.6 in terms of the equivalence ratio.

Auto-Ignition Temperature: It is the reduced temperature needed to start a self-sustained ignition in volatile fuel combinations when an ignition source is absent. For acetylene, the auto-ignition temperature is 305°C. This induces difficulty during the ignition based on the heat only and in the absence of extra ignition resources.

Detonation Power: The detonation power is the extent of external energy that must be provided to ignite a volatile fuel combination. The prevalent reasons for combustion are flames and spark. The acetylene's ignition power is 0.019 MJ, which makes it effortlessly combustible.

Flame Velocity: The flame velocity and adiabatic flame temperature are significant characteristics for engine working and control, especially when thermal efficiency, combustion constancy, and emissions are considered. Flame velocity is characterized by a flame traveling through the combustion gas combination. Flame velocity indicates the relentlessness of a detonation since increased burning velocities have a greater inclination to sustain the changeover from deflagration to explosion in extended subways or conduits. Flame velocity changes with gas concentration and reduces at both the limits of the flammability range. Below the LFL and above the UFL, the flame velocity is nil. The flame velocity of acetylene is 1.5 m/s, which is more than methane or gasoline (at the stoichiometric state). Thus acetylene has an ability to flame rapidly, which is very undesirable.

Quenching Gaps: In a combustion chamber, the flame is quenched from the cylinder wall due to thermal failures at a particular space called quenching distance. This distance is very small for acetylene. Because of this, the quenching of the acetylene flame is very complicated.

Diffusivity: It is the capability of scattering into the atmosphere. The diffusivity rate of acetylene is more than gasoline. It enables the creation of a consistent combination of fuel and air. Secondly, a potential seep-out evolves, which results in quick scattering.

Flame Parameters: Acetylene burns with air with a powerfully hot, incandescent, and murky flame. The combustion temperatures of acetylene combinations change according to the proportion, pressure, water-vapor quantity, and preliminary temperature. The properties of different gaseous and liquid fuels.

Handling and Storage: Acetylene is unbalanced and cannot be contained at high pressures similar to oxygen and nitrogen in conventional cylinders. Acetylene is contained at medium pressures in cylinders filled with a permeable accumulation (acetone), which is termed as DA (dissolved acetylene).

Safety Precautions: Acetylene smolders in the air with a murky flame. It induces thermal energy at high temperatures. The combination of gas and air is very easy to set fire to /explode by means of a small flame, hot spot, or when heated/squeezed above normal working ranges. When used in I.C. engines, the components, including gas feelers, flash prohibition, and flame ensnarements, are used to prevent the explosion of the acetylene.

Material Compatibility: Acetylene creates volatile substances when combined with copper (brass), silver, mercury, calcium hypochlorite, ammonia, halogens, hydrides (sodium hydride, cesium hydride), liquid nitrogen, and potassium.

METHODS OF USE IN IC ENGINES

Acetylene functions as neat fuel in S.I. engines. In CI engines, it can be used in a dual-fuel manner using diesel, biodiesel, or DEE as a combustible origin. As the potential belongs to the homogenous charge compressed ignition engines (HCCI), acetylene is an appropriate choice for the HCCI modality of working(Swaminathan et al. [10]).

Acetylene in S.I. Engines: The increased ignition range of acetylene leads to less throttling compared with petrol. This results in reduced pumping loss and increased thermal efficiency. However, some of the other characteristics like less ignition energy create difficulties in the working of a petrol engine—the lesser ignition power prerequisite results in back-flash in the inlet manifold and also crank-case detonations. Also, the increased level of burning induced elevated crest temperature. It also increased nitric oxide (NOx) emanations.

Acetylene in CI Engines: Using acetylene in a diesel engine proves to be the main obstacle. This obstacle exists in the form of acetylene/air combination ignition due to increased auto-ignition temperature. It would be extremely advantageous to create a methodology for using acetylene in CI engines due to its usefulness in transportation, power generation, and agricultural equipment. Glow-cork or increased compression ratios were considered essential to start ignition. The incineration can also be done using pilot-diesel in the dual-fuel mode. The introduction of acetylene during the suction-procedure and straight-forward induction into the combustion chamber are given by Das [2].

Induction of Acetylene in the Intake System (Carburetion): The easiest modality of injecting the fuel in an acetylene engine is with the help of a carburetor. The methodology is comparable to the S.I. engines. It does not need an enhanced-pressure injector. The complexity of this methodology is its unbalanced burning due to pre-ignition and back-fire. The power yield is also minimal when compared to the regular engines. The representation of the carburetion procedure is revealed in Figue 1.

Acetylene Injection in the Intake System: Acetylene can be fed into the intake with an electronically functional injector. Electronic injectors are good from the design perspective. They exert good control over the injection timing and duration with a faster reaction in high-speed circumstances. The location of the injector on the manifold is decided based on the type of injection system(port fuel injection system or manifold injection system), which is explained by Das et al. [2]. The representative diagram of the manifold injection system is shown in Figure 2. In inlet manifold injection, the fuel is fed into the intake manifold. In the port injection system, the fuel is fed at a distance of 5 mm from the intake valve seat.

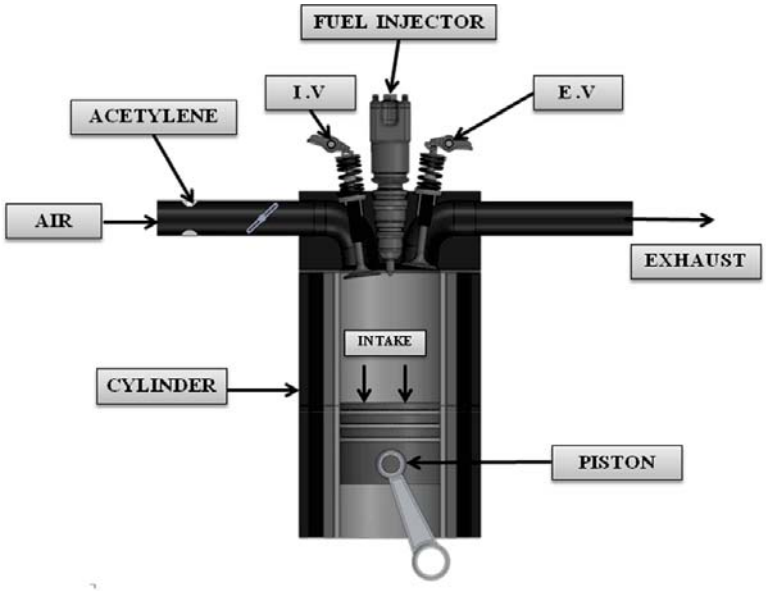

FIGURE 1. Carburetion system

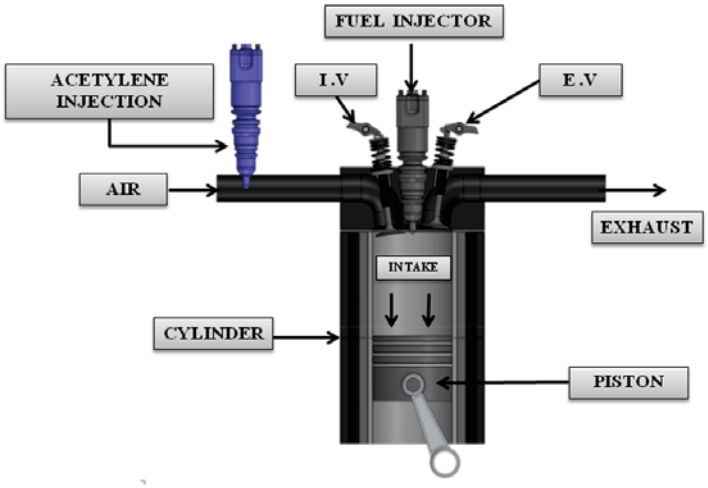

FIGURE 2. Manifold injection system

Figure 3 shows the port injection system. The problems of pre-ignition and back-fire are eliminated due to pre-cooling of hot spots and reduction in the intensity of the hot lingering gases due to the presence of air during the intake stroke. This dual-fuel technique has the asset of effortlessness and suppleness in the present diesel engines.

Direct Injection of Acetylene: The conventional system of straight-forward fuel feed into the suction stroke minimizes the average air charged in the cylinder. Here, the air boosting or direct injection (DI) of the fuel into the cylinder is needed. In the direct injection system (Figure 4), the fuel is fed straight inside the combustion chamber. This is comparable to a diesel fuel injector with the needed pressure at the conclusion of the compression stroke.

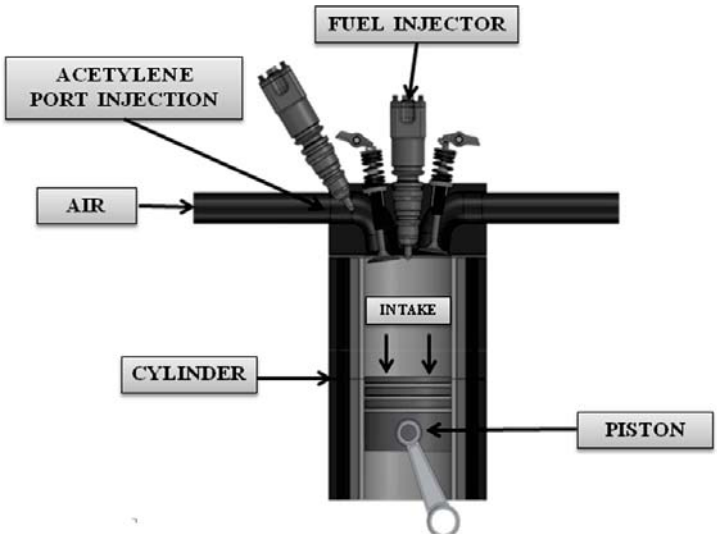

FIGURE 3. Port injection system

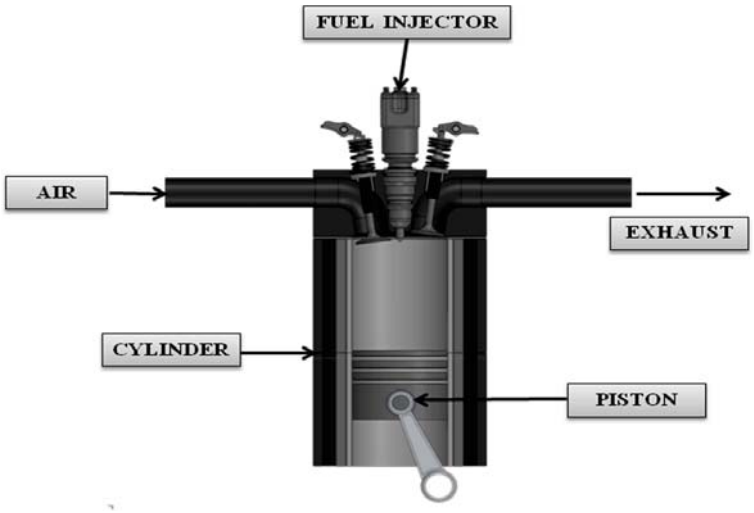

FIGURE 4. Direct injection systems

The high-pressure direct injector feeds the fuel at the conclusion of the compression stroke. For combustion, either diesel or spark-plug is utilized. The main difficulty with the direct injection system is the availability of lesser time for combining the air and fuel, resulting in non-uniformity in fuel proportions. Hence, the competence of the engine reduces slightly during idling or part load states.

CHARACTERISTICS OF AN ACETYLENE ENGINE

Quality Control: The distinctive benefit of using acetylene lies in its ability to vary the fuel to air ratio to fulfill dissimilar forceful states or loads. The manipulation of engine output power by varying the fuel ratio leads to quality control. In SI engines, the volume of the charge is organized.

Thermal Efficiency: As acetylene has extensive flammability ranges, a subdued ignition energy engine can be operated in lean ranges resulting in a maximized fuel cost-cutting measure. In the acetylene engine, increased compression ratios can be accommodated due to the high self-ignition temperature of acetylene. Acetylene engine can also operate more effectively under lean mixtures due to the low ignition energy requirement. The joint influence of the mentioned parameters results in an augmentation of thermal efficiency.

Emanations from Acetylene Fueled Engines: The most important benefit of acetylene vehicles is the emanation of lesser pollutants. The unique characteristic of the gas-functional engine is that it gives very few pollutants when contrasted with SI and CI engines. Acetylene ignition does not result in pollutants like HC, CO, SO_2, lead, particulate substances, and other carcinogenic composites. NOx is the most important emanation from the acetylene operated CI engines. The creation of NOx is due to the usage of ambient air in the combustion chamber. The NOx formation is due to the reaction temperature and duration, and the availability of O_2. The NOx proportions can be reduced using lean mixtures, water injection, exhaust gas recirculation, etc.

TABLE 1. Combustion and physical properties of fuel

Properties	Acetylene	Diesel	Hydrogen	Ethanol	CNG	Gasoline
Empricial Formula	C_2H_2	C_8–C_{20}	H_2	C_2H_5OH	CH_4	C_4–C_{12}
Density (1 atm, 20°C (kg/m^3))	1.092	820–860	0.08	809.9	0.65	720–780
Auto ignition temperature (°C)	305	254	572	363	540	257
Stoichiometric ratio (kg/kg)	13.2	14.5	34.3	9	17.2	14.7
Motor octane number	45–50	–	130	89.7	105	95–97
Min. quenching diameter (mm)	0.85	–	0.9	2.97	3.53	2.97
Adiabatic flame temperature (K)	2500	2200	2400	2193	2320	2300
Maximum flame speed (m/s)	1.5	0.3	3.5	0.61	0.42	0.5
Min. ignition energy (MJ)	0.019	–	0.02	0.23	0.29	0.23
Lower heating value (kJ/kg)	48.225	42.500	120.000	26.700	49.990	43.000
Flammability limits in air (%Vol.)	2.5–81	0.6–5.5	4–74.5	3–19	5.3–15	1.4–7.6

The main merits of using acetylene as gasoline-acetylene mixures in SI engines. Acetylene as a mixture with other fuel it has several advantages in performance and emission characterisitics of a fuel in SI engines. Gasoline-acetylene mixtures can be used in SI engines at low load to full load. Similarly, it can be used as a single fuel at partial loads. Under stoichiometric conditions, acetylene is mixed with gasoline results in decrease in gasoline consumption at steady output power as shown in the table 2. Similarly, figure 5 explains hydrocarbon emissions ware significantly reduced at all loads as shown in the figure 6 and nitrous oxide emissions were reduced at full loads based on the working principles of gasoline. The experimental studies revealed that under stoichiometric ratio under 25, 50, 75% and full load conditions at 1500 rpm NO emissions were reduced. Acetylene can be injected into the intake manifold of test engine through the gas injector 500 and 1000 g/h gas flow rates. Consequently, acetylene increases the poor combustion limit in partial loads in SI engines. SI engines can be operated in leaner conditions with the combination of gasoline-acetylene mixtures. The brake thermal efficiency of the engine increases and the specific fuel consumption decreases as shown in the figure 7 and 8. When combined at high equivalence ratios, reduced the exhaust emissions are observed. Likewise, NO emissions exists in non-existent as in-cylinder temperatures decreases in lean fuel-air mixtures and finally unburned hydrocarbons emissions are reduced when compared gasoline as a single fuel operation in SI engines as shown in figure 9 and 10. In large cities, now-a-days acetylene is used an alternative fuel in SI engines, since air pollutants emissions in the atmosphere due to the usage of fuel in SI engines vehicles was significantly reduced. Acetylene can be used as a fuel in diesel engines with dual fuel mode with slight modification in the engine and reduces NOx, HC, CO and CO_2 emissions, contributing to a significant reduction in fuel consumption. Similarly, acetylene cannot be used a single fuel in diesel engine due to their high compression ratio. Several studies were carried out on four stroke diesel engines with a rate power output of 4.4kW at 1500 rpm with slight modifications in the intake manifold in gas injector as shown in the table 2. Figure 11 represent the experimental set of acetylene as a fuel in engine study with slighter modifications.

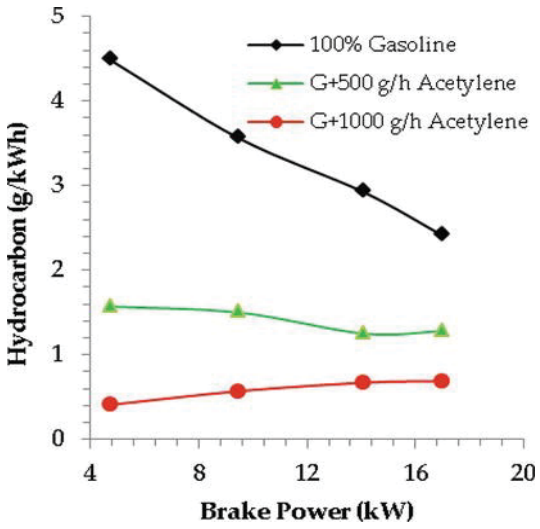

FIGURE 5. Variety of HC with brake power (1500 rpm, different loads) [17]

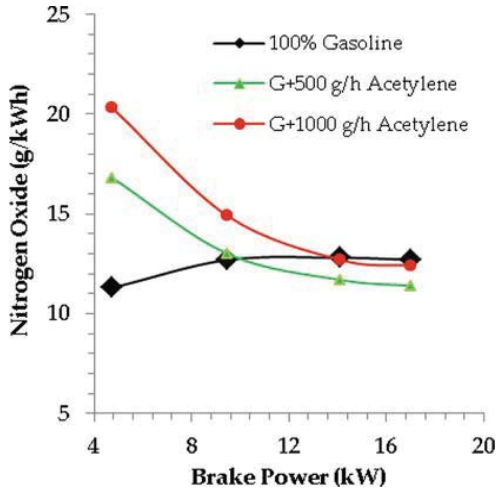

FIGURE 6. Variety of NO with brake power (1500 rpm, different loads) [17]

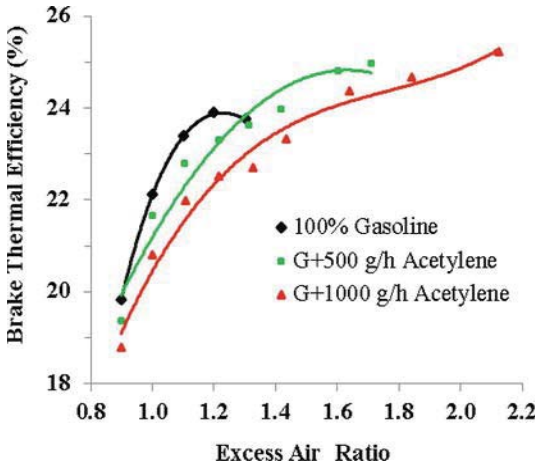

FIGURE 7. The variation of BTE with excess air ratio (1500 rpm, 25% load) [18]

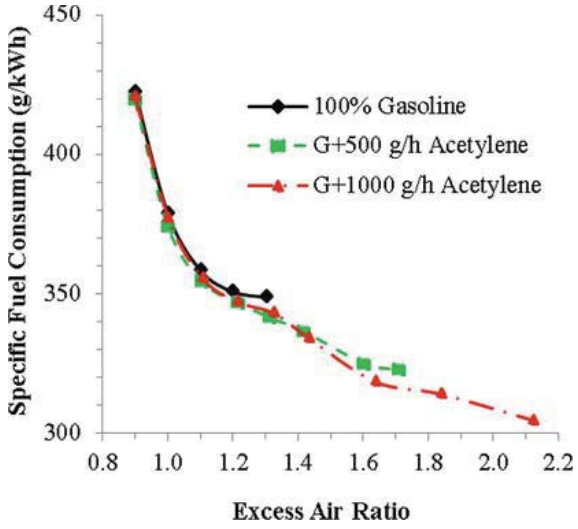

FIGURE 8. The variation of BSFC with excess air ratio (1500 rpm, 25% load) [18]

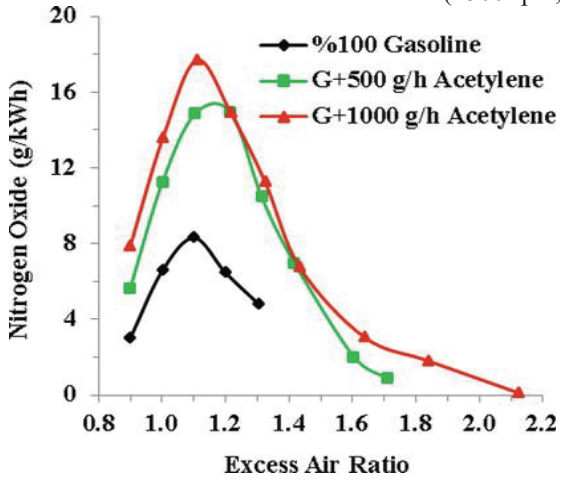

FIGURE 9. The variation of NO with excess air ratio (1500 rpm, 25% load) [18]

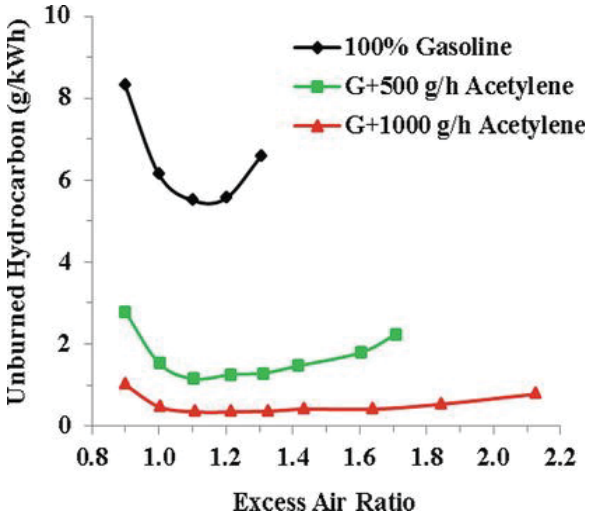

FIGURE 10. variation of UHC with excess air ratio (1500 rpm, 25% load) [18]

TABLE 2. represents the ratio of diesel and acetylene at 240 g/h [4]

Load (%)	Energy equivalent of diesel fuel (kW)	Energy equivalent of acetylene fuel (kW)	Energy share of gas (%)	Energy share of diesel (%)
0	4.01	3.21	44	56
25	5.31	3.21	38	62
50	7.79	3.21	29	71
75	9.33	3.21	26	74
100	10.39	3.21	24	76

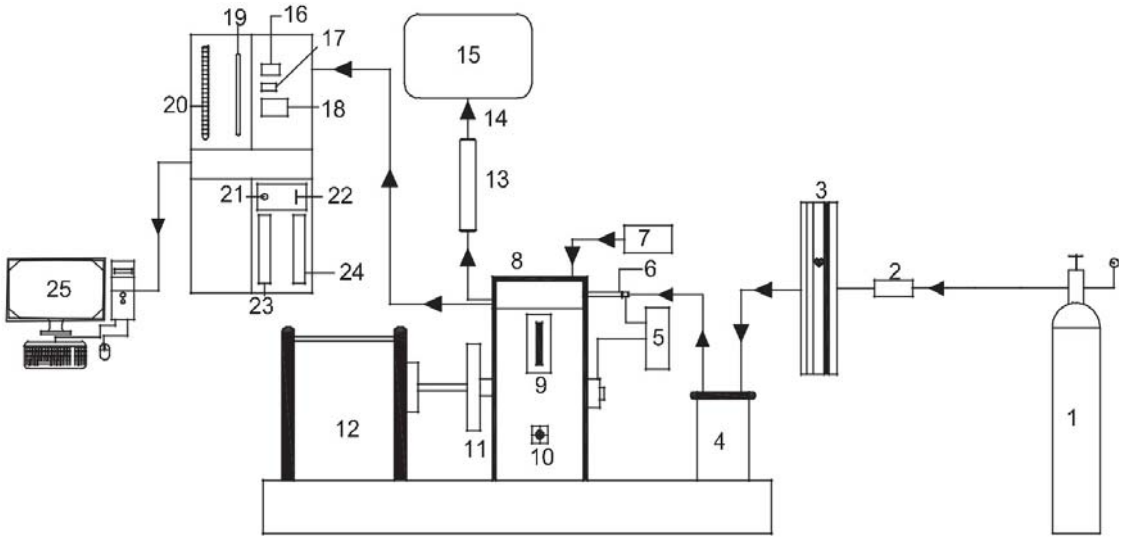

FIGURE 11. Schematic diagram of the experimental setup

Legends

1. Acetylene gas cylinder
2. Flame trap
3. Flowmeter
4. Flame arrestor
5. Electronic Control unit
6. Gas injector
7. Air intake tank
8. Engine
9. C.R. adjustment
10. I.T. adjustment
11. Flywheel
12. Dynamometer
13. Calorimeter
14. Engine exhaust
15. Gas analyzer and smoke meter
16. Digital voltmeter
17. Digital load indicator
18. RPM indicator
19. Manometer
20. Fuel Measuring burette
21. Load Varying knob
22. ON/ OFF switch
23. Engine cooling rotameter
24. Calorimeter cooling rotameter
25. Computer interface

Problems Faced In Acetylene Fuelled Engine: The characteristics which make acetylene attractive for I.C. engine utility also induce abnormal combustion. In particular, the increased flammability ranges, lesser ignition power, and enhanced flame pace can induce unwanted combustion, which is referred to as combustion irregularities. These are untimely ignition, back-firing, and knocking (auto-ignition).The characteristic untimely ignition during the compression stroke resulting from pre-ignition can be attributed to various reasons. The origins of a fresh charge to ignite during the combustion stroke consists of hot exhaust valves or hot spots in the combustion chamber, hot residual gases, and hot oil constituent parts from the preceding ignition proceedings. The pre-ignition is more prevalent when the acetylene air mixture reaches the stoichiometric levels due to the reliance of the lower combustion energy on the equivalence ratio. This untimely ignition results in incompetent and uneven running states. If the untimely combustion happens near the fuel intake valve, the ensuing flame travels back into the feeding

system resulting in back-fire or flashback. The major dissimilarity between back-firing and pre-ignition is the timing at which the complication takes place. Pre-ignition occurs during the compression stroke with the intake valves are already blocked. The back-firing takes place when the intake valves are open. The pre-ignition is the precursor for the incidence of back-firing. Accordingly, any steps that are taken towards the avoiding of pre-ignition results in the reduction of back-firing. At high yield states, the pilot fuel quantity is more. Hence, the ignition basis is strong. The large quantity of pilot fuel entrains a good amount of primary fuel; the gaseous fuel can burn rapidly, releasing extremely high energy and sharp pressure rise, leading to knock. Due to this, NOx emissions emitted from dual-fuel engines at high output conditions will be significant. Knocking depends on various factors like the nature of the primary fuel and pilot fuel, charge quality, and charge temperature.

Steps taken to Prohibit Combustion Irregularities: Standard engine design and mild alterations in the auxiliary engine system can eliminate acetylene ignition irregularities in the CI engine. The steps to be taken to inhibit abnormal irregularities are minimization in concentration of the intake, standard ignition system arrangement, acetylene gaseous fuel injection scheme, minimization of the thermal zones inside the combustion chamber, and increased CR.

Charge Dilution Techniques: Preliminary ignition can be minimized by various methods like re-rotation of exhaust gas, water feed, etc. The Exhaust gas recirculation(EGR) method reuses a particular volume (maximum of 20%) of exhaust vapor into the intake manifold to minimize the temperature, equivalence ratio, and the likelihood of pre-ignition. Another method is water feed. It is found that inducing water into the intake manifold provided excellent results when compared with the feed of water into the cylinder. Methodologies capable of thermally watering down the charge like water injection and resultant exhaust gas re-using are deployed to eliminate back-fire and auto-ignition concurrently.

Spark Plug Arrangement: The standard arrangement of the spark plug consists of the voltage-gap, cooling, and proper basis of the ignition wires to eliminate inductance.

Injection System: It was viewed that the TMI systems present an alternative for the load management method with the help of throttling. The systems have the capacity to start fuel delivery at a timing location after the initiation of the intake stroke. The system was thus created so that the intake manifold is devoid of combustible mixtures, which eliminates the undesirable combustion phenomena. The TMI system is created to induce the air before the induction of fuel. This induces a pre-cooling effect making the pre-ignition sources ineffective. Furthermore, it assists in the extinguishing and watering down of any remaining ignition products present in the compression zone near the TDC. An acetylene induced engine having a timed TMI system has advantages for both petrol and diesel engines. During the experiments, it was revealed that the system had the exclusive potential of diesel-like excellence governing. It produced a thermal efficiency similar to CI engines and met specific power requirements similar to petrol engines. The Acetylene direct feed into the combustion chamber is another step to minimize or completely remove the incidence of pre-ignition based on injection plans.

Hot Spots: It is very significant to note that the hot spots in the combustion chamber can start surface ignition or back-fire, which should be evaded. The steps taken to achieve this include the timed manifold and direct injection. These steps are sufficient to postpone the fuel induction. This preliminarily cools the hot-spots by means of the suction air. Also, sufficient foraging done by the variable valve timing reduces the remaining gas temperatures.

Compression Ratio: The selection of the best compression ratio is a desirable characteristic of any fuel. The CR should be chosen in the optimal zone to maximize the engine efficiency with the ranges provided by the augmented thermal failures or the anomalous ignition.

CONCLUSION

The research presented in this manuscript provides a reasonable opportunity for the implementation of acetylene in CI engines. The acetylene used engine does not get hampered in providing the desired yield when compared with the conventional engines. From the emission perspective, the acetylene is seen as the best except for NOx. Also, it is evident that the timed injection is important for successful acetylene handling. However, several research works need to be undertaken with variations in compression ratio, ignition timing, and valve timing, for complete scrutiny of the appropriateness of acetylene in both SI and CI engines. Acetylene also has an exceptional benefit in the form of committed accumulation when compared with other vapor fuels. It can be accumulated in a solidified state in

calcium carbide. Based on the need, acetylene can be produced in a limited time period by adding water. However, running the engine with acetylene proves to be slightly pricey since the operational costs are 1.2 times higher than the conventional diesel. When calcium carbide is created with renewable energy rather than electrical energy, its manufacturing cost will be minimized. A breakeven point will definitely be reached for acetylene usage in CI engines in the future.

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Is Robotics Education and Training Gender Dependent? A Suggestive Robotics Syllabus for Teacher Training

G S Prakasha*, Joseph Varghese Kureethara, Anthony Kenneth and Peter Varkey Muttungal
Christ University, Bangalore, India
https://orcid.org/0000-0002-1287-7606
https://orcid.org/0000-0001-5030-3948
https://orcid.org/0000-0001-7798-2389
https://orcid.org/0000-0002-1953-3830

Trent Grundmeyer
Drake University, Des Moines, Iowa, USA
https://orcid.org/0000-0002-0747-2276

Abstract. Application of robotics is rapidly increasing in all fields of life. Though robotics education became popular in the 21st century, its teaching and training has not gained much importance across the world, especially in developing and low-income countries. There are various reasons for its neglect and one of them could be gender-science stereotypes. Research studies are yet to explore the reasons for its slow emergence. The present study explores the need and training for educational robotics considering the role of students, teachers, teacher-educators and parents, determining whether it is gender-dependent or not. The study also proposes to come up with a syllabus for robotics training. The study employs exploratory, sequential, qualitative-quantitative mixed-method research design and applies purposive sampling techniques. Researchers conducted semi-structured interviews, including five science teacher-educators, five science teachers, and five trainee teachers majoring in sciences to understand the need, scope and benefits of robotics education. They recruited 100 high school students, 50 teacher-educators, and 100 parents to test whether their interest in robotics is gender-dependent through Chi-square analysis. The study revealed the need for robotics education under four themes and seven subthemes. It has been found that the interest of students and parents and the readiness of teacher-educators for robotics education is gender-dependent. The study came up with a suggestive syllabus for robotics training. It recommends that future

* Corresponding author: *G S Prakasha, prakasha.gs@christuniversity.in*

researchers should focus on the implementation of robotics teaching for teacher and school education.

Keywords: educational robotics; robotics training; robotics syllabus; gender-science stereotype

1. Introduction

Educational robotics is a modern pedagogical tool to be included in teaching and learning. 21st century learners need to learn high quality science, technology, engineering, and mathematics (STEM). As technology advances, the products resulting from such advancement permeates educational fields and students would use them in the learning process, from elementary to higher education (Casey et al., 2018). Robotics education promotes students' interest in STEM subjects (Khanlari, 2013). It is also conceived as a branch, which deals with educating students to create and design robots (Vicente et al., 2021). The primary aim is the ability to create robots via programming and adding various functional responses. Students use a robotics kit, which is appropriate to their age (Vega & Cañas, 2018). The subject is a notable means to promote academic achievements in the field of STEM (Afari & Khine, 2017) and STEAM (Science, Technology, Engineering, Arts and Mathematics) subjects (Hinojo-Lucena et al., 2020). Robotics education can promote aconstructivist classroom learning and create an active learning environment (Barak & Assal, 2018). In addition, it can be used to promote skills such as: creativity and spatial memory skills, psychomotor skills (Alemi et al., 2020), collaborative learning (Chootongchai et al., 2019), creativity (Yi, 2019), entrepreneurship (Blackley & Howell, 2019), and project-based learning skills (Caballero-González & García-Valcárcel, 2020).

2. Review of Literature

A study on the attitude of students towards robotics found that girls have less robotics learning desire and confidence than boys (Kucuk & Sisman, 2020). Another study by Sullivan showed that robotics teaching in K-12 education enhances scientific knowledge among students (Sullivan, 2008).The use of robotics in primary education has significantly increased students' confidence and interest in science and technology (Zviel-Girshin et al., 2020). A study by Karypi (2018) showed that robotics education develops a positive attitude towards STEM and boosts cognitive and social skills of learners, making them more independent, active, and motivated. Another study by Tsagaris et al. (2019) indicated that participants are happier and more satisfied in learning science and other school subjects via robotics rather than through conventional methods. They learn to cooperate and enjoy learning through playing with robotics.

Robotics education is emerging as a pedagogical approach to science teaching. A systematic review related to applying robotics in school education clearly articulated the presence of robotics in western education since 2000 (Kubilinskiene et al., 2017). Teacher education must emphasise the need for educational robotics training, and train future teachers to incorporate multi-platform-approaches in robotics teaching (Boyarinov & Samarina, 2020) and design approach to promote easy learning. Educational robotics activities are

easier to use when programmed based on behaviour-based approach (De Cristoforis et al., 2013). Studies have shown the need for robotics in higher education and termed them as an "innovative approach' towards teaching subjects like sciences and engineering (Sánchez et al., 2019). A study by Gorakhnath and Padmanabhan (2017) on educational robotics introduced educational robotics teaching and learning, leading to an understanding of the teacher's engagement.

The gender stereotype has existed in vocational choices since the last two to three decades and will remain persistent (OECD, 2017). The global gender gap report from the World Economic Forum confirms the underrepresentation of women in STEM fields (WEF, 2017). Gender stereotypes believe that women are born to pursue humanities and men should study technical fields (Charles & Bradley, 2009). Indian women too are dropping out from STEM education and careers for various indigenous reasons (Hammond et al., 2020). A study asked pre-service teachers to teach primary school children with robotics and technology. It revealed that teachers gained confidence and knowledge, which helped them to integrate technology in their classrooms (Chalmers et al., 2012).

3. Theoretical Framework

Theoretical frameworks that guided the present study include Social Identity Theory (SIT) and Social Role Theory (SRT). The central idea of the social identity theoretical framework is that people compare themselves by forming in-groups (us) and out-groups (them) to enhance their self-image (Tajfel & Turner, 1979). This involves three-stage mental processes in the order of social categorisation, social identification, and social comparison. In social categorisation, people group themselves in order to understand the social environment. In social identification, humans adopt the identity of the group they belong to and in social comparison, they compare their own with other groups and try to maintain self-esteem on par with others. Similarly, in the present study, students, teachers, teacher-educators and parents have an implicit understanding of the group they belong to and process their behaviour accordingly. Consequently, gender-science stereotypes are evident. The social role theory suggests that the gender role is visible every day. People observe the roles of men and women and thereby form their own beliefs leading to gender stereotypes (Eagly & Wood, 2012).

4. Context of the Study

In India, robotics education is a value-added programme in school education rather than a part of the school's curriculum. One gets use to see robotics in science exhibitions, science fairs, science competition, science club events, and in engineering education, but not in the school's curriculum, bearing in mind that teachers have no training to complement their classes with educational robotics pedagogy. In spite of several research studies on robotics as a pedagogy of science teaching, it is missing in mainstream school education. Teacher preparation colleges never attempted to include robotics training in their curriculum. Govinda, (2020), while emphasising STEM education, did mention the need for robotics teaching and training at all levels.

Though robotics has been in India since a decade, there are not many serious discussions to utilise its benefits for science education. This could have several reasons, such as traditional Indian culture, non-materialistic value systems, huge population, financial deficit, educational infrastructure, and lack of awareness and human resources. India has the highest youth population and investments in robotics education would have been productive. Additionally, there are facts such as female literacy rate being lower than male. There is also a gender-science stereotype belief. There are more number of female teachers than male. As men opt for professions other than teaching, there are more female science teacher educators than male. There is also less representation of women in the field of science, STEM education, and engineering as in many other countries (Gupta, 2019). Some of the reasons for this include family decisions, economic issues, gender stereotypes, social differences, social expectations, male domination, and lack of role models (Gupta, 2019; Wang & Degol, 2017).

Therefore, the present study attempts to understand low representation of women in science education, more female representation as science teachers and science teacher-educators and women as parents affecting the prevalence, acceptance, and emergence of robotics education. There is a need for proper planning of robotics education, how it could be included, what content can be included, who will teach, and what kind of training is needed for pre-service and in-service teachers. Schools in India, which recognised the value of robotics education, have added it as an optional value-added programme. But a huge number of schools still lack awareness of robotics education and teachers too lack training. Therefore, the present study aims to:

- Explore the need, importance, benefits, and training of educational robotics;
- Test whether high school students' interest, teacher-educators' readiness, and parents' interest in robotics education is gender-dependent or not; and
- Frame a syllabus including theory and practicum to train teacher trainees majoring in sciences in the teacher education programme.

5. Methods

The study employed an exploratory, sequential, qualitative-quantitative mixed method research design to address the research objectives that were framed. Researchers obtained institutional, ethical clearance and followed all the necessary ethical guidelines during each type of data collection.

5.1. Qualitative Method

5.1.1. Research Design

To explore the need, importance, benefits, and training of educational robotics, the study employed phenomenological interpretative research design.

5.1.2. Participants

The study used convenient sampling techniques and selected 15 participants for the interview - five science teacher educators, five teacher-trainees majoring in sciences at the Bachelor of Education program, and five in-service science teachers at secondary schools. The researchers assigned pseudonyms to the

participants as P1, P2… and P15. Table 1 presents the demographic characteristics of the interviewees.

Table 1: Showing the demographic details of the participants

Sl. No	Designation	Age	Gender	Teaching/learning subject
P1	Teacher Educator	40	M	Physics
P2	Teacher Educator	42	M	Chemistry
P3	Teacher Educator	35	M	Biology
P4	Teacher Educator	38	F	Mathematics
P5	Teacher Educator	52	F	Physics
P6	Teacher trainee	25	M	Physics
P7	Teacher trainee	28	M	Chemistry
P8	Teacher trainee	30	M	Biology
P9	Teacher trainee	26	F	Mathematics
P10	Teacher trainee	29	F	Physics
P11	School teacher	25	M	Science
P12	School teacher	30	M	Science
P13	School teacher	35	M	Science
P14	School teacher	32	F	Science
P15	School teacher	38	F	Science

5.1.3. Interview Guide

The researchers developed a semi-structured interview guide as per the objective of the study and validated it with a panel of experts, involving senior professors from three reputed universities. Table 2 presents the interview guide used for the study.

Table 2: Interview guide

Questions for teacher educators

- Why do you think robotics education is important for STEM education?
- Should teacher education programs preparing science teachers have training in educational robotics? Explain
- What are the other benefits of educational robotics?
- Why do you think there is a need for robotics labs in teacher education programme?

Questions for secondary school teachers

- Why do you think robotics education is important for STEM education?
- Should teacher education programmes preparing science teachers have training in educational robotics? Explain
- What are the other benefits of educational robotics?
- Why do you think there is a need for robotics labs in schools?

Questions for secondary school teacher trainees majoring in sciences

- Why do you think robotics education is important for STEM education?
- Should teacher education programmes preparing science teachers have training in educational robotics? Explain
- What are the other benefits of educational robotics?
- Why do you think there is a need for robotics labs in a teacher education programme?

5.1.4. Data Gathering Procedure

One of the authors of the study, who holds a PhD in education and has 20 years of experience, conducted the interviews via online video-conferencing platforms such as Cisco WebEx/ Google Meet, while a few were telephonic. At the beginning of each interview, the researcher explained the purpose of the study and obtained consent from participants. The researchers gave participants the privilege to withdraw from the interview at any point of time if they were not comfortable. The researchers assured the participants of anonymity, safety, and confidentiality of data. They conducted semi-structured interviews with a funnelling approach to understand the need for robotics education. The funnelling approach helped the researchers to elicit in-depth information. Interview recordings and transcripts were stored safely with password protection and are available only to researchers.

5.1.5. Data Analysis Procedure

Researchers read and re-read the transcripts several times to carry out inductive analysis of the data. Consensus from all the researchers have evolved with major themes and subordinate themes (Marshall, 1999) presented in Table 4 of the result section. The Figure 1 below shows the inductive analysis coding process used in the study and is adapted from Creswell (2002).

Initial reading of the transcripts	**Identifying specific part of the transcripts**	**Labelling and creating categories**	**Refining the categories**	**Creating models with major themes and subthemes**
Full text	Part of the text	15 categories emerged	Retained 8 categories	4 major themes and 7 sub-themes

Figure 1: Showing the inductive analysis coding process

5.2. Quantitative Method

5.2.1. Research Design

To test whether the high school students' interest, teacher educators' readiness and parents' interest in robotics education is gender dependent or not, the study employed descriptive survey research design.

5.2.2. Research Informants

Researchers observed that many schools in India have recently started robotics coaching as an extra-curricular activity, while some schools are still planning it. One researcher adopted purposive sampling techniques and selected a school, which is starting robotics coaching. He selected 50 males, 50 females and their parents. To obtain the opinions of teacher educators, the study used snowball-sampling method and selected 25 male and 25 female teacher educators of science pedagogy in teacher education colleges across the country.

5.2.3. Survey Instrument

The researcher constructed a dichotomous response type opinionnaire, which included a consent form, demographic information and opinion statements. The

study established face and content validity of the opinionnaire with a panel of experts. Table 3 below displays the items of the opinionnaire.

Table 3: Survey opinionnaire

Demographic details: Gender – Male /Female		
Items	**Dichotomous response**	
Student: Are you interested in the robotics coaching that your school is going to start	Yes	No
Parent: Are you admitting your child to robotics education coaching, which the school is going to start	Yes	No
Teacher educator: Are you ready to train your teacher trainees through robotics pedagogy if robotics theory and practicum are included in the syllabus	Yes	No

5.2.4. Data Collection Procedure

The researcher collected the opinion of 50males and 50 females about their interest in robotics education and recorded their responses. The investigator also collected the opinions of their parents related to their interest in enrolling their children to robotics coaching at school. There were 100 parents altogether, with equal representation by male and female parents. In order to maintain the objectivity of data and to avoid bias, parent's responses were kept confidential and did not disclose anything to the child or the partner parent. The researcher also collected the opinions of 50 teacher educators (25 males and 25 females) using convenient sampling on their readiness to train science teacher trainees through robotics. The study analysed the collected data using Chi-square test of association. It helps in confirming the observed relationship with respect to the expected relationship. Chi-square test of independence is suitable, as there are two dichotomous variables - gender and interest/investment in robotics education.

In order to address the third research objective, researchers planned to construct a syllabus unit including fundamental concepts on robotics and its practicum. The syllabus must help to initiate robotics education and training in teacher training programmes. It could be a part of science elective syllabus to train teacher trainees majoring in sciences. Researchers developed a draft syllabus and checked it for its face and content validity. One of the researchers facilitated the inter-rater reliability process of the constructed syllabus. The facilitating researcher employed a snowball sampling technique to select the panel of subject experts for inter-rater reliability analysis. The facilitating researcher in consultation with other researchers selected 20 expert teacher educators involved in preparing science teachers at teacher education colleges. The researchers briefed the panel about the research purpose, circulated the draft syllabus to the expert panel members and obtained their agreement and suggestions against each content item of the proposed syllabus, using a rating scale ranging from one to ten points. The inter-rater reliability statistics have been applied to find the reliability of the constructed syllabus. Table 11 in the result section presents the result of reliability statistics. The final draft of the

syllabus incorporated the suggestions provided by the experts (Mahajan et al., 1976). Appendix1 presents the final framed syllabus and practicum.

6. Results and Discussion

6.1. Results of Qualitative Analysis

Table 4 below represents the themes and subthemes evolved out of inductive analysis of the semi-structured interview data, addressing the need and importance of robotics education and training.

Table 4: Showing the themes and subthemes

1. Robotics education
    a. Importance
    b. Scope
2. Robotics training
    a. Unexplored
3. Benefits of robotics education
    a. Quality science education
    b. Innovation
4. Robotics lab
    a. Investment
    b. Practicum training

This section discusses the essential features of the main theme and subtheme evolved out of the inductive analysis method from the interview transcripts of teacher educators, teacher trainees and teachers. The essential features involved the meaning of themes and subthemes, key characteristics, text samples, and review supports.

Main Theme 1: Robotics Education

Science, Technology, Engineering, and Mathematics (STEM) education has gained importance all over the world in the last two decades. Robotics change the way students learn STEM subjects and make them more knowledgeable and well-adjusted. Robotics attracts students to STEM education and brings fun, enjoyment, and satisfaction in learning. It captures student attention and interest and provides satisfying learning experiences (Eguchi, 2010).

a) Subtheme: Importance

Teacher educators, teacher trainees, and science teachers have unanimously mentioned that robotics is the future pedagogy for STEM education. It brings variety to the classroom and engages students actively in science learning. It encourages innovation and critical thinking. It also develops problem-solving ability.

P1 – […] Robotics boosts students' interest in sciences…
P13 - […] it brings innovation…

b) Subtheme: Scope

As technology advances, the use of robotics increases in all occupations. Students learn through the play-way method. It helps learners to understand abstract science concepts. It utilises both cognitive and social constructivist

approaches, and enhances the computational thinking of students, which is necessary for a science career. The scope of application of robotics education is beyond imagination. With the advancement of technology, concepts like cloud computing, artificial intelligence, gamification, face-recognition, voice-recognition, and numerous innovative applications have a wide scope of application in learning sciences.

Main Theme 2: Robotics Training

Schools these days are providing robotics education in various ways, such as after-school programmes, summer camps, weekend programmes, and value-added programmes, as they believe that it benefits students' academic performance (Rusk et al., 2008). Scandinavian countries such as Europe, UK and US have national directives to provide robotics education and enhance the quality of education. Students using robotics have excelled in STEM subjects and have won global robotics competitions for their innovative ideas. Science teachers are expected to guide students to participate in robotics competitions, but they lack knowledge in guiding them. Therefore, to strengthen the quality of science education, including robotics training for science teacher trainees in their pedagogical subject or in educational technology is the need of the hour.

a) Subtheme: Unexplored

Teacher educators and science teachers have mentioned that teacher education programmes must explore the opportunities to provide training in educational robotics. Even students have suggested that teachers could use robotics in science classes. Two of the female teacher educators (P4 and P5) have expressed their own doubts about robotics education, which has the potential to trigger innovation and discoveries. National policies of teacher education in a few countries of the world have taken steps to involve robotics training in their teacher education programs and recently India in its new NEP (2020) mentioned it.

> *P7 - […] it is helpful if our professors teach us robotics…*
> *P4 – […] it sounds good but we do not have any professional training on it …*
> *P5 – […] I doubt whether teacher educators would like it…*

Main Theme 3: Benefits of Robotics Education

Robotics education inspires children to learn the subject and attracts them towards STEM subjects. Students get to learn coding skills along with it. They become more proactive, scientific, and acquire problem-solving skills. It is an active teaching-learning pedagogy, which helps in recognising students' creative talent and boosts their confidence in learning sciences.

a) Subtheme: Quality Science Education

Both teacher educators and teachers said that robotics is the best method of teaching STEM subjects. As certain science concepts are abstract, robotics helps to understand them and develops original thinking habits among students. It develops interest in STEM subjects and provides ideas for innovation. It triggers critical and creative thinking and collaborative learning opportunities (Blikstein,

2013). It also helps people to participate in competitions such as science fares and exhibitions at the national and international level.

P6 – […] it is helpful in participating at science competitions…
P12 – […] it provides first-hand experience in learning…Science subjects…

a) Subtheme: Innovation

Teachers, teacher educators, and teacher trainees believed that robotics develops a scientific attitude, scientific temper, and makes students feel like young scientists. It provides a platform for youngsters to become leaders in educational technology. There are many young student inventors who have become youthful programmers, application developers and drone makers. Robotics education is often the medium to communicate their scientific ideas. It is the reason why schools in the 21st century have subscribed to educational robotics as an extracurricular activity, and believed it would be supplementary to their academics.

Main Theme 4: Robotics Lab

The robotics lab helps in STEM education, which is part of a progressivist curriculum, leading to innovation in science and technology. Educational institutes must invest in establishing robotics lab and provide coaching at all levels of education. Training science teachers without educational robotics is perhaps an incomplete teacher-training programme. Teacher education has to setup robotics labs with fundamental gadgets, computers, and necessary online platforms. Teachers have to acquire the knowledge of conducting robotics practicum.

a) Subtheme: Investment

Teacher educators, teacher trainees and teachers have voiced the need for investment in basic robotics equipment, which has multipurpose applications. Teacher education institutes can upgrade their technology lab with robotics instruments. Schools may also open a robotics lab to encourage science learning. Many of the European schools have invested in FAB-LABs, Gamification LAB, and Robotics Lab (Cornetta et al., 2020).

b) Subtheme: Practicum Training

Teachers mentioned that hands-on training by teacher educators to teacher trainees majoring in sciences would help them use educational robotics at schools. Having trained in robotics education will enhance their job opportunities, while teaching robotics through projects and opportunities for professional development are plenty (Sullivan, 2008). Successful projects or winning in robotics events will give job satisfaction and there will be more interest and ideas to innovate. Teacher educators also mentioned that it is time to provide robotics training in teacher preparation programmes, which must include theory and practicum.

P1- robotics lab is interesting…we can also have it in the technology lab…
P8 - Robotics lab experience will make us confident teachers…and it will be useful in terms of job prospectus…

6.2. Results of Quantitative Analysis

This section covers the results of Chi-square test of association to understand whether high school students' interest, teacher educators' readiness, and parents' interest in robotics education is gender dependent or not. Tables 5 and 6 present the results of cross tabulation and Chi-square test measuring the null hypothesis. There is no association between high school students' gender and their interest in robotics education.

Table 5: High school students * Interest in robotics education cross tabulation

			Interest in Robotics education		Total
			Interested	Not interested	
High school students	Males	Count	36	14	50
		Expected Count	28.0	22.0	50.0
	Females	Count	20.0	30.0	50.0
		Expected Count	28.0	22.0	50.0

Table 6: Chi-square tests for high school students * Interest in robotics education

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	10.390[a]	1	.001		
Continuity Correction [b]	9.131	1	.003		
Likelihood Ratio	10.589	1	.001		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	10.286	1	.001		
N of Valid Cases	100				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 22.00.					
b. Computed only for a 2x2 table					

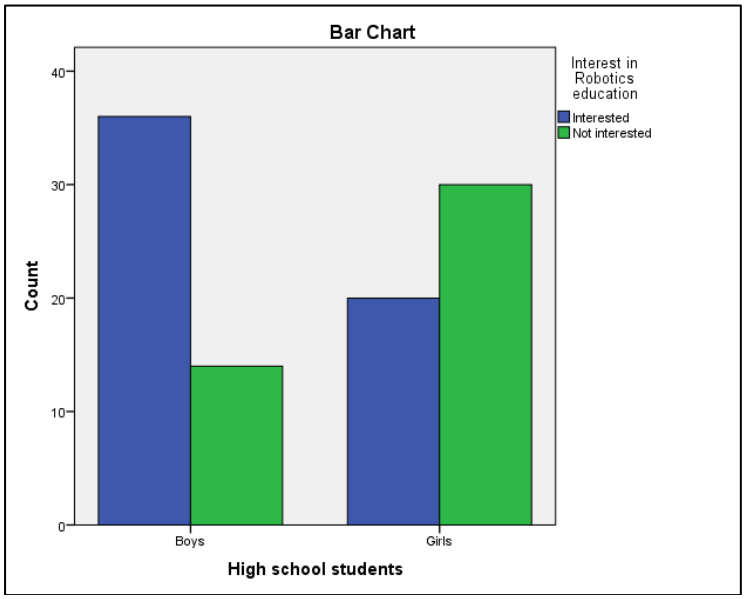

Figure 2: High school students' interest in robotics education

From the Tables 5 and 6, it is clear that all the expected cell frequencies are less than 28, therefore we infer from Fisher's exact test. There is a statistically

significant association between high school students' gender and their interest in robotics education, $\chi 2$ (1) = 10.390, Fisher's exact tests p = .002. Cramer's V value = 0.332 and its p = 0.01 indicating the size of the effect is medium. It is also evident from Figure 2.

Table 7 and 8 below present the results of cross tabulation and Chi-square test measuring the null hypothesis; there is no association between teacher educators' gender and their readiness to include robotics education in teacher education programme.

Table 7: Teacher educator * Inclusion of robotics Education Cross Tabulation

			Inclusion of Robotics Education		Total
			Yes	No	
Teacher Educator	Males	Count	18	7	25
		Expected Count	12.0	13.0	25.0
	Females	Count	6	19	25
		Expected Count	12.0	13.0	25.0

Table 8: Chi-Square Tests for Teacher Educator * Inclusion of Robotics Education

	Value	df.	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	11.538[a]	1	.001		
Continuity Correction [b]	9.696	1	.002		
Likelihood Ratio	12.033	1	.001		
Fisher's Exact Test				.002	.001
Linear-by-Linear Association	11.308	1	.001		
N of Valid Cases	50				
a. 0 cells (.0%) have expected count less than 5. The minimum expected count is 12.00.					
b. Computed only for a 2x2 table					

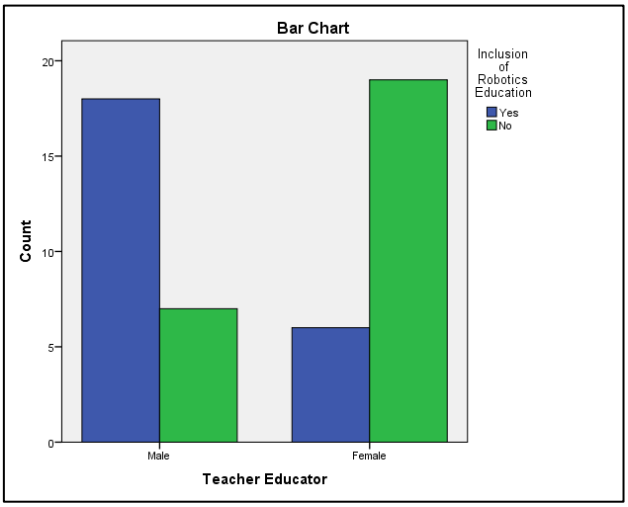

Figure 3: Teacher educators' readiness to include robotics education

From the Tables 7 and 8, it is found that the expected cell frequencies differ from observed cell frequencies and are greater than five, and therefore we infer from Pearson Chi-square value. There is a statistically significant association between

teacher educators' gender and their readiness to include robotics education in teacher education programme respectively, $\chi 2$ (1) = 11.538, (Asymptotic Significance) p = .001. Cramer's V value = 0.480 and its p = 0.001 indicating the size of the effect is large (Kim, 2017). It is also evident from Figure 3 above.

Tables 9 and 10 below display the results of cross tabulation and Chi-square test measuring the association between parents' gender and their interest to invest in robotics education for their high school children.

Table 9: Parents gender * Interest to invest in robotics coaching cross tabulation

			Interest to invest in robotics coaching		Total
			Yes	No	
Parents' Gender	Males	Count	76	24	100
		Expected Count	58.0	42.0	100.0
	Females	Count	40	60	100
		Expected Count	58.0	42.0	100.0

Table 10: Chi-Square Tests Parents' gender * Interest to invest in robotics coaching

	Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)
Pearson Chi-Square	26.601[a]	1	.000		
Continuity Correction [b]	25.144	1	.000		
Likelihood Ratio	27.298	1	.000		
Fisher's Exact Test				.000	.000
Linear-by-Linear Association	26.468	1	.000		
N of Valid Cases	200				
a. 0 cells (0.0%) have expected count less than 5. The minimum expected count is 42.00.					
b. Computed only for a 2x2 table					

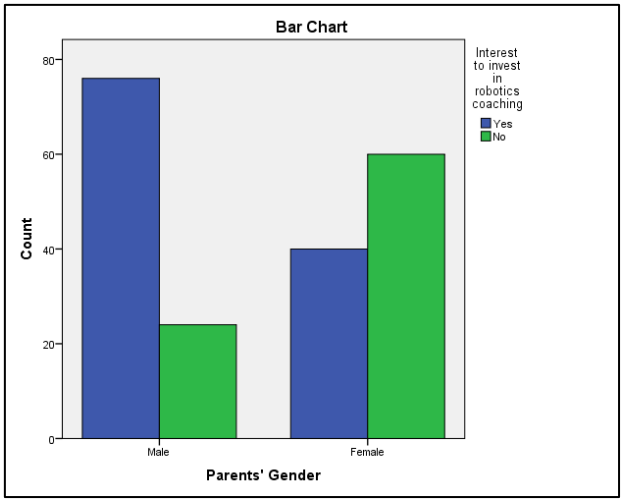

Figure 4: Parents' gender and interest to invest in robotics education

From the Tables 9 and 10, it is clear that the expected cell frequencies differ from observed cell frequencies and are greater than five, which means that we infer

from Pearson Chi-square value. There is a statistically significant association between parents' gender and their interest to invest in robotics education for their high school children, $\chi 2$ (1) = 26.601, (Asymptotic Significance) p = .000. Cramer's V value = 0.365 and its p = 0.000 revealing that the size of the effect is almost large (Kim, 2017). It is also evident from Figure 4 above.

Inter-rater Reliability

The present study employed the inter-rater reliability method to finalise the syllabus framed. Researchers initially constructed the draft syllabus and checked it from its face validity and content validity among themselves. It was then processed for inter-rater reliability analysis. Accordingly, the researchers created a panel of experts who are science teacher educators, with equal representation to gender. Teacher educators willing to participate in the study were only included in the panel. Researchers briefed all the teacher educators about their purpose. After obtaining their informed consent, the draft syllabus has been shared with 20 science teacher educators, out of which 10 were male and 10 were female. Teacher educators responded to the draft syllabus on a 10 points rating scale, ranging from least to appropriate and gave their suggestions wherever necessary.

The investigators subjected the inter-rater ratings to intra-class reliability analysis. They found the Alpha value of 0.984 indicating the high reliability of the constructed syllabus. Table 11 below shows the results of intra-class correlation coefficient analysis.

Table 11: Intra-class correlation coefficient

	Intra-class Correlation [b]	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Single Measures	.753[a]	.600	.895	62.123	12	228	.000
Average Measures	.984[c]	.968	.994	62.123	12	228	.000
Two-way mixed effects model where people's effects are random and measures' effects are fixed.							
a. The estimator is the same, whether the interaction effect is present or not.							
b. Type C intra-class correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.							
c. This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.							

From the above table, all the 20 raters had almost 98% agreement with the constructed syllabus. However, if you take a single measure, an agreement of 75.3% is obtained for each item of the constructed syllabus (Morgan et al., 2004).

This mixed method research revealed the perspectives of teacher educators, teacher trainees, and secondary school science teachers on the need and scope of robotics education. The inductive analysis of the interview data came up with four main themes and seven subthemes highlighting the need and scope of robotics education. The themes have revealed the need for robotics education, as

it develops better understanding of science concepts, applications, and captures the interest and attention of learners.

All the participants readily agreed that robotics education is the future of science and students have to be educated on its use. Participants strongly believed that there is a need for investment in robotics labs and for practical training for students. It enhances students' critical thinking ability in sciences and paves the way to innovation. It provides them a sense of the global competitive spirit and develops a scientific temper in them. However, a few of the female teacher educators expressed their own doubts about its implementation.

The study also observed that Indian traditional and cultural aspects and gender-science stereotypes affect the prevalence and implementation of robotics education. The study revealed that boys have shown more interest in robotics education than girls. Parents' interest in investment in robotics education for their children has the influence of gender. Similarly, teacher educators' readiness to include robotics education as part of their programme is also influenced by gender. The study found that in spite of several research studies, discussing the benefits of educational robotics, its acceptance and implementation as part of the school's curriculum is suffering from gender-science stereotype. Teacher education colleges have not thought of initiating robotics training in their programmes nor attempted to create any syllabus. The study clearly pointed out the need for systematic planning, awareness, and a positive attitude towards providing robotics education and training. The study urged that the female audience should break this stereotyped mindset and participate in science education, irrespective of its nature, and the male audience need to encourage and accommodate women in science education. The present study brought out a suggestive syllabus on robotics education and suggestive practicum activities to be included in the training of teacher trainees majoring in science subjects. The study hopes that teacher education authorities would receive it positively and take steps to implement the suggested syllabus and the practicum. The new NEP (2020) has also emphasised the need for robotics education in schools and colleges (Govinda, 2020; Nandini, 2020). The study recommends that future researchers should work towards setting up robotics labs and include robotics education as part of school and college curricula.

7. Conclusion and Implication

Educational robotics is a way forward for STEM and STEAM education and attracts students to pursue higher education in the sciences, which contributes to the economic development. Unfortunately, higher education in sciences is suffering from gender-science stereotypes across the globe. The present study clearly reveals the need for robotics education from students', teachers', parents', and teacher educators' perspectives through a qualitative method. The study clearly confirms the presence of gender-science stereotype in affecting the prevalence and emergence of robotics education. Students' interest towards robotics learning, parents' interest in investing in robotics coaching for their wards, and teacher educators' readiness to offer robotics training to teacher trainees majoring in sciences are gender dependent. The study suggests a valid

syllabus and training practicum on educational robotics to initiate robotics training at teacher education colleges. The study limited the opinion on robotics education from teacher educators, teacher trainees, teachers, students, and parents. It emphasises the need for investment in educational robotics, eliminating gender-science stereotypes and developing a positive attitude towards robotics education. The present study urges stakeholders to implement robotics in schools, colleges, and in teacher education. Only if robotics is added to the teacher preparation curriculum would teachers have the skills and knowledge to prepare students for the 21st century.

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Appendix1

Inter rater Reliability Pro Forma with Robotics Teacher Training Syllabus

Syllabus content		Rater rating																			
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	Unit title: Introduction to Educational Robotics	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9	9
2	Meaning and nature of Educational robotics	8	8	7	8	7	8	7	8	8	7	8	8	7	8	8	7	8	8	7	8
3	Theories behind educational robotics	9	8	5	8	7	8	6	6	6	10	8	7	7	7	7	7	7	7	7	7
4	constructivism and constructionism	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
5	Potentials of robotics in education	9	8	8	8	7	8	8	7	6	10	9	7	7	6	7	7	6	7	6	7
6	Applications of robots in daily life	9	9	8	9	8	9	9	8	9	9	8	9	9	8	8	9	9	8	9	9
7	Demonstration of a robotics package	8	7	6	8	7	6	7	7	8	6	8	8	8	8	8	8	8	8	8	8
8	Fundamental programming for robotics	6	6	5	5	6	5	6	6	7	6	8	6	6	5	6	6	7	6	6	6
9	Making decision and Loop control behaviors' in computer programs	9	8	7	9	8	7	9	9	8	8	7	9	7	9	8	7	9	9	8	9
10	Time required teaching the unit: 10 hours	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
11	Practicum - Creating a Robot	9	8	9	9	8	8	9	8	9	8	9	9	8	8	8	9	9	8	9	9
12	Time required for Practicum 10 hours	10	10	10	9	10	10	10	10	9	10	10	10	8	10	10	9	10	10	9	10
13	**Practicum details** Teacher educator to demonstrate Robot construction plan, which involve creating a scenario, sketching a plan, executing the plan using robotics kit. After demonstration, the teacher educator may invite teacher trainees majoring in science to come up with a scenario in which robotics intervention needed, discuss the plan with teacher educator, draw a schematic diagram of the plan, chose the materials required to build the robots from the available robotics kit, construct the robots, and execute (Daniela et al., 2014). The teacher educator and trainee then hold a debriefing session to discuss the pros and cons of the constructed robot and its utility. Teacher trainees then use the robotics kit on multi-principle platforms such as Lego mind storm NXT package, Make block Ultimate Robot Kit-Blue, Bioloid STEM standard kit, Arduino Robot Kit, Sun Founder Crawling Quadruped Robot DIY Kit for Arduino Part with Nano Board Remote Control etc.																				
14	**Suggestions:**																				

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ONLINE TEST ANXIETY AND EXAM PERFORMANCE OF INTERNATIONAL BACCALAUREATE DIPLOMA PROGRAMME STUDENTS UNDER E-PROCTORED EXAMS AMID COVID-19

G S Prakasha
Christ University, India
E-mail: prakasha.gs@christuniversity.in

KY Hemalathaa
Syracuse University, USA
E-mail: ky.hemalathaa88@gmail.com

Ponni Tamizh
Oakridge International School, India
E-mail: tamizhponnicit@gmail.com

Bhola Bhavna
Heritage Xperiential Learning School, India
E-mail: bhavii1983@gmail.com

Anthony Kenneth
Christ University, India
E-mail: anthony.kenneth@ed.christuniversity.in

Abstract

Outbreak of COVID-19, online examination, and e-proctoring have caused more exam anxiety and affected exam performance among students' studying in International Baccalaureate (IB) Diploma Programme (DP). Therefore, the present research aimed to find effect of online test anxiety on academic performance of IBDP students in the subjects related to science, technology, engineering, and mathematics (STEM). Study employed quantitative descriptive survey research design and administered survey questionnaire to 200 IB DP students who took online test during COVID-19 through convenient sampling technique. Sample included both first and final year DP students with due representation to boys and girls. Results of the study revealed a moderate negative correlation between online test anxiety and academic performance of IBDP students in STEM subjects. Regression analysis explained 14.1% variation in the STEM subject performance because of online exam anxiety under e-proctored condition. There exists a statistically significant difference between first and final year students' online exam anxiety and STEM subject average grades. Future research may focus on conducting comfortable online examination methods with no additional exam anxieties.

Keywords: *International Baccalaureate (IB), Diploma Programme (DP), e-proctored test, virtual examination*

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Introduction

Ever since the Covid-19 pandemic broke out, countries across the globe started to impose various restrictions in order to curb the infection rates (Gonzalez et al., 2020). Institutions around the world were faced with closures with an estimated 1.6 billion students from 180 countries ceasing to attend schools (Panovska-Griffiths et al., 2020). During such a catastrophic and unexpected scenario many institutions resorted towards rejuvenating the education system via the online mode of instruction (Crawford et al., 2020). Teachers proceeded towards conducting classroom lectures online (Abidah et al., 2020). The pandemic gave opportunities for digitally immersed education. Conferences, examination, lectures, and student-teacher interactions are now occurring virtually (Kumar, 2020; Strielkowski, 2020). The concept of Online learning or e-learning is not relatively new and is historically originated as an alternative for students who could not attend face-to-face teaching-learning (Wedemeyer CA, 1981). However, this started to gain significant recognition over the past decades with numerous studies and research exploring online learning (Daffin Jr. & Jones, 2018; Marshall, 2008; Roddy et al., 2017).

Assessment is a vital component of teaching-learning, it is often considered by students as a measure of their success for their academic performance (Boud, 1990) but the restrictions imposed due to lockdowns posed a major challenge for assessment (OECD, 2020). Initially, countries were compelled to postpone the examinations for the higher education (Butler-henderson & Crawford, 2020) but due to the increase in infectivity rates globally, institutions resorted towards online testing via 'e-proctoring' in order to assess students. Monitoring students over the internet through electronic tools remotely for examinations or test refers to 'Virtual proctoring or e-proctoring' (Pathak, 2016). This mode of online assessment is deemed to be effective and reduces mal-practice (Dendir & Maxwell, 2020). This mode of proctoring usually monitors the candidate audio and video feed obtained from their gadgets (Webcam, microphone) and their progress on the computer by mirroring their screens. E-proctoring software prevents the candidate from opening other tabs or apps in the background (Caballero-González & García-Valcárcel, 2020). Online proctoring is of two types: automated or live proctoring. In live proctoring, the students are monitored in real time by a particular assigned proctor remotely. Software flags any unusual physical activity or eye movements or nearby phone, indicating mal-practice. In automated proctoring, the proctor is not constantly monitoring the students, rather any forms of suspicious activity indicating mal-practice are recorded and reviewed later (Hussein et al., 2020; Raman et al., 2021). Both these types are applicable for assessments, but live proctoring can be suggested as a better option due to constant monitoring which prevents any imposter taking the test on the candidate behalf (Nie et al., 2020). Even though tests like the GMAT, LSATS and the TOEFL have adopted online testing via e-proctoring methods to cater students to attend these tests from the comfort of their homes. Schools and colleges need to understand the nuances of online testing in terms of procedures to be followed, kind of questions to be set, assessment schemes and so on. Online testing and E-proctoring are already prevalent in many MOOCs and the surging demand also paved the way for newer sophisticated software which was seen replacing (Alessio et al., 2018; Daffin Jr. & Jones, 2018) the once dominated modes of virtual proctoring such as video conferencing (Hylton et al., 2016; Weiner & Hurtz, 2017). Platforms like the Mettl, Proctorio, Examity, Proctoru, and Proctortrack have gained significant recognition during the pandemic (Ching, 2020). They replaced the online virtual video conference proctoring to a software based proctoring (Alessio et al., 2018; Daffin Jr. & Jones, 2018). Newer online testing software has features such as proctoring, question paper releasing, answer script submission, anonymity of student submissions, and evaluation system. Halem et. al. (2021) says it would be surprising to view the future that replaces the traditional human proctored examination by virtual mode.

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Globally, student population is faced with high level of anxiety and stress (Afsar & Kulsoom, 2015; Bayram & Bilgel, 2008). Even though the impact of Covid-19 has brought about deteriorating effects on the mental health of the population (Roy et al., 2020; Xiao, 2020) and measures were taken to diagnose such issues, the mental health among the students was relatively ignored (Lee, 2020; Xiang et al., 2020). While some studies showed that teachers and students provided positive feedback on online proctoring (Craig et al., 2020; Munshi et al., 2020; Reid & Sam, 2020) the newer practice of evaluating the students online was adding on the existing issues in the prevailing education system during the pandemic (Cao et al., 2020; Talidong & Toquero, 2020). Studies revealed that anxieties related to examinations and tests are the most common forms amidst students in the higher education (Furr et al., 2001) and often displayed in the form of discomfort, sadness, and regret. These emotions piled up as a result from previous test experiences and affect the self-esteem and motivation of oneself (Sari et al., 2018; Stöber, 2004; Larreamendy-Joerns & Leinhardt, 2006; Sansgiry & Sail, 2006). Even causing students to drop-out or instigate suicidal tendencies (Schaefer et al., 2007). Given the current issues that online mode of learning is faced, which is aggravating the further inequality in education (Jæger & Blaabæk, 2020; Thomas & Rogers, 2020). Studies during pandemic pertaining to online teaching, online learning, and online testing have mostly focused on technological support needed for them. Whereas students studying in crucial academic stage like grade 11 or 12 have suffered the consequences of this initial technological adaptation. Therefore, there is a need for in-depth understanding of consequences faced by students due to online teaching and testing. Thus, present study aims to understand whether e-proctored online testing has created exam anxiety among students and thereby affected their academic performance.

Context of the Present Study

The IB Diploma programme is a globally recognized university entry qualification. Students studying in this programme have a well-defined plan for their higher studies and usually join the top universities around the world. Students who opted higher level Mathematics and Sciences in the diploma programme aim to take up their higher studies in STEM education. Outbreak of Covid-19 has left them disturbed. Nevertheless, it forced students onto online classes, e-proctored online examination, and its evaluation. This situation is not limited to IB school board alone but may be true for the other school boards as well. Researchers of the study have witnessed it and therefore have planned to conduct the present research. Researchers were quite inquisitive to know whether e-proctored online test caused anxiety among students and affected their performance in pre-board examination. There is also gender-science stereotype in many parts of the world as reported by world economic forum (WEF, 2017). Researchers in the present study also planned to see the differences in online test anxiety and performance in STEM subjects based on gender. Results of the present study have potential to inform the IB and other education system on anxiety faced by the students in remote testing and the way their performance was affected especially at their crucial stage of school education.

There exists a negative correlation between exam anxiety and exam performance as per the reviews around six decades. However, in the present study the conditions are different due to Covid-19. Students are used to face-to-face examination and were asked to take up online examination all of a sudden therefore, it certainly adds on to the usual exam anxiety. E-proctoring these online exams further aggravates it. Students studying in IB DP are usually from a higher socio-economic status. They are hoping to join higher education in the best universities of the world. Therefore, measuring situational anxiety gains importance, and performance of students seriously matters at this crucial educational stage in their lives. Students who have opted for STEM subjects are generally hoping for a bright future in sciences. Outbreak of Covid-19

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has brought a lot of uncertainty in students' academic future. Therefore, present study was an attempt to understand whether online exam anxiety under e-proctored condition is affecting their performance especially in STEM subjects.

Research Objectives

- To find whether there is a relationship between online test anxiety faced by the IB DP students and their academic performance.
- To find out whether the variation in academic performance is explained by e-proctored online test anxiety faced by the IB DP students.
- To find out whether there is any difference in online test anxiety and academic performance in STEM subjects among boys and girls
- To find out whether there is any difference in online test anxiety and academic performance in STEM subjects among first year and final year IB DP students

Hypotheses

- There is no significant relationship between online exam anxiety and academic performance in STEM subjects of IB DP students
- Online exam anxiety is not a significant predictor of academic performance of IB DP students in STEM subjects
- There is no significant statistical difference between online exam anxiety and academic performance in STEM subjects of IB DP boys and girls.
- There is no significant statistical difference between online exam anxiety and academic performance in STEM subjects of first and final year IB DP students

Research Methodology

General Background

The present study employed quantitative descriptive research survey design to address the research objectives framed for the study. The study planned to collect data from the survey questionnaire during the pre-board examination of IB DP students, which is planned to be conducted online on an e-proctored mode. The study sample is limited to the IB students of first and final year diploma programme. Researchers included students from only those schools, which accepted our request to conduct the study. Usually, number of students in IB DP is less unlike other school boards. Therefore, the sample size is limited to 200 only altogether.

Sample

Study employed convenient sampling technique and planned to collect data from international schools located in India and offering IB diploma programme. Study included 200 students studying in IB diploma programme, which includes 78 boys, 122 girls, 61 first year diploma students, and 139 from final year diploma programme. Study included only those who have taken STEM related subjects for their diploma programme. Study sought permission from the schools, first, for collecting the data and then from students and their parents. It included assent form for students and consent form for parents. Study also sought institutional ethical clearance to conduct the present study. Researchers assured the confidentiality of the data collected to the school heads, students, and their parents. The data is encrypted and is accessible only to the researchers.

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Instrument Used

The present study used online test anxiety inventory (OTAI) developed by Alibak et. al. (2019) to measure the test anxiety of IB DP students before their pre board exams. Researchers verified the adequacy and suitability of the instrument by obtaining the face and content validity of the items from a panel of experts. The study established reliability of the instrument using Cronbach alpha reliability statistics and found reliability coefficient of 0.892, which indicates that the instrument is highly reliable (Nunnally, 1979).

Data Collection Procedure

Researchers visited the schools selected for the study and obtained permission from the heads of the schools to collect the required data. Researchers circulated the survey questionnaires to first year and final year IB DP students of the schools prior to their pre board online examination. Survey questionnaire had consent forms and social demographic details in the first section and second section had items of OTAI instrument. Researchers assured anonymity of the data collected to students, parents, and school authorities. Out of the total responses, the researchers included 200 completely filled responses for the study. Once the pre board examination and its evaluation were over, the researchers collected, students' average-score grades of STEM related subjects. Researchers cleaned the data and then fed into SPSS version 24 to carry out the quantitative data analysis.

Data Analysis

The study used correlation test, simple linear regression analysis, independent sample t-test, and analysis of variance (ANOVA) test to test the statistical significance of the hypotheses framed for the present study. The results are presented in the following section.

Research Results

Researchers conducted Pearson correlation test to find out the relationship between online test anxiety and academic performance of IB DP students. Nevertheless, the study tested whether the obtained relationship is true even in case of demographic variables such as gender and studying year of IB DP. Table 1 shows the results of the correlation test.

Table 1
Pearson Correlation Statistics

Variables	Performance in STEM Subjects				
	Overall	Boys	Girls	First year DP	Final year DP
Online Test anxiety	-.376**	-.283**	-.433**	-.374**	-.333**

**. Correlation is significant at the .01 level (2-tailed)

As shown in Table 1, there is a moderate negative correlation between online test anxiety and performance of students in STEM subjects (r = -.376). To any increase in online test anxiety there is a corresponding proportionate decrease in the performance in STEM subjects' grade.

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Online test anxiety negatively correlated to boys, girls, first year, and final year DP students' performance in STEM subjects. All these negative correlations are statistically significant at .01 level.

The regression analysis was to understand the total variation in the Performance of students in STEM subjects (dependent variable) as explained by the online exam anxiety under e-proctored condition (independent variable). Research data met all the assumptions required of regression analysis. As shown in Table 2, it is clear that the correlation between student performance in the STEM subjects and their online exam anxiety is 0.376 indicating moderate correlation. 14.1% of the variation in students' performance in STEM subjects' is because of the online exam anxiety they have under e-proctored condition (Quirk, et al., 2021).

Table 2
Model Summary Statistics of Regression

Model summary[a]						
Model	*R*	*R* Square	Adjusted *R* Square	Std. Error of the estimate	Change statistics	
					R Square Change	*F* change
1	.376[a]	.141	.137	1.15705	.141	32.584

a. Predictors: (Constant), Exam anxiety

Durbin-Watson statistical test conducted to find out the auto-correlation in the residuals from regression analysis. The result of the auto-correlation between online exam anxiety and STEM subjects' average grade points presented in Table 3 shows that there is a slight positive autocorrelation (1.785) between the variables.

Table 3
Durbin-Watson Statistics

Model	**Change Statistics**			Durbin-Watson
	df1	*df2*	*Sig. F Change*	
1	1[b]	198	.0001	1.785

b. Dependent Variable: STEM subjects average grade points

ANOVA output of the regression analysis presented in Table 4 explains how well the regression equation and model fits the data. Regression model significantly predicts the dependent variable ($p < .05$) that means online exam anxiety predicts performance in STEM subjects.

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Table 4
ANOVA Statistics

ANOVA[a]						
Model		Sum of Squares	*df*	Mean Square	*F*	*p*
1	Regression	43.622	1	43.622	32.584	.0001[b]
	Residual	266.076	198	1.339		
	Total	308.698	199			

a. Dependent variable: STEM subjects average grade points (Exam performance)
b. Predictors: (Constant), Exam anxiety

The regression model coefficients presented in Table 5 determine whether online exam anxiety statistically significantly contributes to the model. As shown in Table 5 online exam anxiety contributes significantly to the model and is able to predict students' performance in STEM subjects. A regression equation formed out of the unstandardized coefficients (B) value is; STEM subjects average grade point = 6.540 + (-0.033) x (exam anxiety).

Table 5
Showing Regression Coefficients Statistics

Coefficients [a]								
Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*p*	95.0% Confidence interval for *B*	
B		Std. Error	Beta			Lower bound	Upper bound	
1	(Constant)	6.540	.281		23.243	.0001	5.985	7.095
	Exam anxiety	-0.033	.006	-.376	-5.708	.0001	-0.044	-.021

a. Dependent variable: STEM subjects average grade points

In order to test whether there is any difference in online exam anxiety and academic performance in STEM subjects among boys and girls studying in IB DP, the study conducted independent sample t-test. Table 6 shows the results of the independent sample t-tests.

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Table 6
Independent Sample t-Test for Exam Anxiety and Academic Performance with Gender

		Levine's Test for Equality of Variances		t-test for Equality of Means						
		F	*p*	*t*	*df*	p (2-tailed)	Mean Difference	Std. Error Difference	95% CI Difference Lower	95% CI Difference Upper
Exam anxiety	Equal variances assumed	.016	.898	.427	198	.670	.892	2.090	-3.229	5.014
	Equal variances not assumed			.425	161.219	.672	.892	2.102	-3.258	5.042
Performance in STEM subjects	Equal variances assumed	.100	.752	-1.115	198	.266	-.20120	.18045	-.55705	.15466
	Equal variances not assumed			-1.123	168.327	.263	-.20120	.17909	-.55475	.15235

Table 6 shows that, there is no significant difference in online exam anxiety among boys and girls studying in IB DP (t_{198} = 0.427, p = 0.670). Therefore, the null hypothesis is accepted, and alternative hypothesis rejected. Nevertheless, there is no significant difference in academic performance in STEM subjects among boys and girls studying in IB DP (t_{198} = -1.115, p = 0.266). Therefore, the null hypothesis is accepted, and alternative hypothesis rejected.

In order to test whether there is any difference in online exam anxiety and academic performance in STEM subjects among first year and final year students studying in IB DP, the study conducted independent sample t-test. Table 7 shows the results of the independent sample t-tests.

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Table 7
Independent Sample t-Test of Exam Anxiety and Academic Performance with II and I DP

		Levine's Test for Equality of Variances		t-test for Equality of Means						
		F	*p*	*t*	*df*	*p* (2-tailed)	Mean Difference	Std. Error Difference	95% CI Difference	95% CI Difference
									Lower	Upper
Exam anxiety	Equal variances assumed	.010	.919	2.714	198	.007	5.903	2.175	1.614	10.193
	Equal variances not assumed			2.718	115.038	.008	5.903	2.172	1.602	10.205
Performance in STEM subjects	Equal variances assumed	.316	.575	-3.547	198	.0001	-.65959	.18595	-1.02629	-.29290
	Equal variances not assumed			-3.471	109.044	.001	-.65959	.19006	-1.03628	-.28291

Table 7 shows that there is a significant difference in online exam anxiety among first and final year IB DP students ($t_{198} = 2.714$, $p = .007$). Therefore, the null hypothesis is rejected, and alternative hypothesis is accepted. Online exam anxiety of first year DP students' is more than final year students' ($M_{first} = 51.33$, $M_{final} = 45.42$). Nevertheless, there is a significant difference in academic performance in STEM subjects among first and final year IB DP students ($t_{198} = -3.547$, $p = .0001$). Therefore, the null hypothesis is rejected, and alternative hypothesis is accepted. Performance in STEM subjects of first year DP students' is less than final year students' ($M_{first} = 4.5451$, $M_{final} = 5.2047$).

Discussion

In the past two decades, there is an increase in the online educational programmes in western education system especially in United States and Canada. This is posing a challenge to exam integrity and there is variation in exam anxiety of the learners. Earlier studies mention that to save time and to make examinations cost effective, many educational programmes do conduct e-proctored online examination. Several survey research have shown that learners misconduct if they get a chance and on contrary to this, if e-proctored method is used to reduce misconduct during online testing, there is additional exam anxiety (Witherspoon et al., 2012; Karim et al., 2014). Studies since last 4 decades have found that test anxiety negatively affected academic performance (Huberty, 2009). In the study conducted by Cassady (2009) it is found that, test anxiety is a situation specific type of trait anxiety. Therefore, measuring test anxiety during Covid-19 pandemic situation gains unique importance and especially with International baccalaureate diploma programme students who are aspiring to join the world's best higher education Universities. Interestingly present study found 14.1% of their performance is affected by additional test anxiety, which is huge in an educationally competitive world.

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Study revealed a negative correlation between online test anxiety and overall performance in STEM subjects and it is true for subgroups of the sample: boys, girls, first year, and second year IB DP students. This result is in agreement with the recent study conducted in an US university (Woldeab & Brothen, 2019). Earlier studies clearly suggested exploring the relationship of online test anxiety and exam performance, accordingly the present study found that, online exam anxiety under e-proctored condition has affected the students' performance in their examination. 14.1% of variation in the exam performance is due to online exam anxiety faced by the students under e-proctored condition. This test anxiety as supported by earlier study is, a condition or situation specific (Cassady, 2010). Study revealed that online exam anxiety is the same across boys and girls. Their performance in STEM subjects also did not differ. However, there is a significant difference in online exam anxiety between first year and final year IB DP students under e-proctored condition. First year students have shown more anxiety than final year DP students have. This could be due to the unexpected prevailing covid situation and perceived online test anxiety and uncertain future ahead.

Nevertheless, first year students' performance in STEM subjects is lower than the final year students' performance as they had higher anxiety. The proctor intrusiveness causes higher anxiety as explained by Woldeab and others (Woldeab et. al., 2017). Overall, online exam anxiety affected the academic performance of IB DP students, therefore schools have to work towards the strategies to reduce online exam anxiety. Induction programmes on nature and procedures of online examination may help students overcome their anxiety. Counselling support programmes to deal with academic pressure, global competitions, coping-mechanisms, and mental health techniques may help in reducing anxiety of students, which in turn may enhance their performance in the upcoming examination be it final board exams and entrance examination. Interestingly pre-university college (PUC) board in Karnataka state of India gave their final PUC results based on student's performance in their grade 10, first PUC, and internal assessments in final PUC. Being Government college education board, it did not go for any online testing and e-proctoring system. As diploma programme is a crucial stage of their school education and determines their future education, stakeholders must pay attention to the outcome of the present study. The study strongly recommends qualitative research to capture the detailed account of their anxiety affecting performance, which helps the stakeholders to take care of such future situations.

Conclusions and Implications

As intended, the study was able to find the relationship between online test anxiety and students' performance in STEM subjects in an e-proctored online examination and it is negative. Further exploration of the relationship found that, online test anxiety explained 14.1% of exam performance. The study revealed that, there is no difference in online test anxiety and exam performance in STEM subjects with respect to gender. However, the differences were found in online test anxiety and exam performance in STEM subjects between first year and final year IB DP students. Few of the limitations of the study are: the study included exam performance in STEM subjects only, drawn sample from students studying in international baccalaureate diploma programme only, and socio demographics considered are gender and study years only. The study can be conducted to a larger sample and to different types of student populations for more comprehensive results. However, the study clearly points out the need for taking careful steps by stakeholders while taking academic decisions especially in 11 and 12 grades level of education. The study recommends future researchers to work on reducing proctor intrusiveness and develop newer technologies for tensionless conduct of remote or online examination.

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Conflict of Interest

The authors have no conflicting interest towards this publication. All have contributed to the work. The authors thank all those who cooperated for the data collection.

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G S Prakasha *(Corresponding author)*	PhD, Assistant Professor, School of Education, Christ University, Bangalore, India. E-mail: prakasha.gs@christuniversity.in ORCID: https://orcid.org/0000-0002-1287-7606
K Y Hemalathaa	MA, Research Scholar, Syracuse University, USA E-mail: ky.hemalathaa88@gmail.com ORCID: https://orcid.org/0000-0001-9739-4445
Ponni Tamizh	BE, Assistant Teacher, Oakridge International School, India. E-mail: tamizhponnicit@gmail.com ORCID: https://orcid.org/0000-0002-2549-2983
Bhola Bhavna	MSc, Assistant Teacher & Counsellor, Heritage Xperiential Learning School, India. E-mail: bhavii1983@gmail.com ORCID: https://orcid.org/0000-0002-1287-7606
Anthony Kenneth	MSc, Scholar, Christ University, India. E-mail: anthony.kenneth@ed.christuniversity.in ORCID: https://orcid.org/0000-0001-7798-2389