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Science and Technology Education for Sustainability and Social Justice

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XXI IOSTE 2024

Science and Technology Education for Sustainability and Social Justice

11 – 15 November 2024 Venue WATERFRONT HOTEL KUCHING, SARAWAK, MALAYSIA

Organised by

Ministry of Education, Innovation and Talent Development, Sarawak (MEITD), The International Organisation for Science and Technology Education (IOSTE) and Universiti Teknologi MARA, Malaysia

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IOSTE Organization

The International Organisation for Science and Technology Education (IOSTE) is an international organisation which aims to encourage informed debate, reflection on and research into science and technology (S & T) education. IOSTE was established in 1979 to promote contact and dialogue across political and ideological

borders. A key concern is that education in S & T should be a vital part of the general education of the peoples of all countries.

IOSTE has a board (committee) with representation from all regions of the world and convenes international as well as regional symposia. These symposia provide for scholarly exchange and collaboration.

The symposia gather researchers, policy makers, teachers and others who are concerned about how science and technology can contribute to the outlined in our mission statement.

The International Organisation for Science and Technology Education was established to advance the cause of education in science and technology as a vital part of the general education of the peoples of all countries and to provide scholarly exchange and discussion in the field of science and technology education. Consistent with our mission to encourage the peaceful and ethical use of science and technology in the service of humankind, IOSTE opposes the use of science and technology by government or other organisations for military purposes against civilians. Its origins can be traced to a Symposium on World Trends in Science Education convened in August 1979 in Halifax, Nova Scotia, Canada. At the third symposium, held in Brisbane (Australia) in 1984, the informal circuit of 'World Trends' was transformed into a formal organisation with members from over sixty countries.

Today, IOSTE has members from about eighty countries, and is officially recognized by UNESCO as a non-governmental organisation. Membership of the International Organization for Science and Technology Education is open to all who subscribe to its Constitution.

Constitution of the International Organisation for Science and Technology Education

The International Organisation for Science and Technology Education is an international organisation which aims to encourage informed debate, reflection and research on science and technology (S&T) education. IOSTE was established in 1979 to promote contact and dialogue across political and ideological borders. A key concern was that education in S&T should be a vital part of the general education of the peoples of all countries.

IOSTE Mission Statement

IOSTE identifies science and technology education with the real and changing needs of humankind as a whole and with specific needs of its component communities and nations.

IOSTE wants to continue and strengthen its tradition and considers that S&T education should:

- Highlight S&T education for citizenship and for informed, critical, and active participation in democracy
 - Emphasise the relationship between science, technology and society
 - Emphasise the cultural and human values of S&T
 - Promote equity in S&T and S&T education
 - Advance S&T education for a just and sustainable development and consider how S&T education can contribute to the fight against poverty, discrimination and injustice
 - Encourage the peaceful and ethical use of S&T in the service of humankind
 - Encourage cultural diversity and international understanding through S&T education
 - Stimulate international collaboration in the domains of research and development and promote cooperation with other international organisations.

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PREFACE

A happy and warm welcome to you all to the XXI International Organisation for Science and Technology Education (IOSTE) 2024 in Kuching, Sarawak, Malaysia. Twelve years ago, I attended the XV IOSTE 2012 in Yasmine Hammamet, Tunisia supported by Sarawak Convention Bureau to bid for the next symposium to be hosted in Kuching. Ten years has passed since XVI IOSTE Borneo 2014, we are back in Kuching in between 4 other symposia in Braga, Portugal (2016), Malmö, Sweden (2018), Daegu, South Korea (2020) and Recife, Brazil (2022). The only symposium that I did not attend physically was in Daegu, South Korea due to the unprecedented COVID19 pandemic.

A wave of nostalgia swept over me when I think of Recife, Brazil. Not only going there completed my journey to all the continents of the world, I took over the chair of the Organization from Prof Dr Agnaldo Arroio from the University of São Paulo, Brazil. Since then, the new board has faced many issues and challenges, and some have yet to be resolved. Taking over to organise the symposium, within a year of preparation, it has been very great that we have been able to make the XXI IOSTE happens. This conference would not have been possible without the unfaltering support of a great team behind me. Everyone in the organisation had contributed in one way or another to undertake the formidable task that ultimately led us to where we are.

Science and technology education appears to be not able to catch up with the manifold crises that threaten our world: climate change, feeding the world population and geopolitical conflicts. In addition, in the growing world economy in both emerging and developed countries, there are critical global needs for the well-educated in science, technology, engineering, and maths (STEM). Thus, the theme *Science and Technology Education for Sustainability and Social Justice* has been chosen with a Roundtable Discussion on "Is STEM really too hard"? This symposium has gathered researchers, policy makers, lecturers, teachers and others who are concerned about how STEM can contribute to the IOSTE mission statement.

The organising committee coming from the Executive Board of IOSTE, Universiti Teknologi MARA (UiTM), Institute Teacher Education of Malaysia, Institute Teacher Education, Batu Lintang Campus, Institute Teacher Education, Tun Abdul Razak Campus and the Invention and Design Association, Sarawak are very honoured to have the Minister for Education Innovation and Talent Development, Sarawak, The Honourable Dato Sri Roland Sagah Wee Inn as our Patron. The support from the Business Event Sarawak is invaluable. There are also many other prominent people, strong advocates of the science and technological learning community who have assisted along the way and by not mentioning them is by no means that they have been forgotten.

On behalf, I take this opportunity to record my appreciation to the keynote speakers, invited speakers, presenters and reviewers of the papers submitted. We strongly believe that this conference will be a remarkable success with the attendance of the rest of you as participants.

Associate Professor Dr Margaret Chan Kit Yok Universiti Teknologi MARA Sarawak

AN INTERVENTION STUDY ON PRIMARY STUDENTS' SOCIOSCIENTIFIC DECISION-MAKING REGARDING THE RISKS AND BENEFITS OF GENE DRIVES

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ABSTRACT

We developed socioscientific issues-based instruction units for primary school students to encourage decision-making regarding the risks and benefits of gene drives. Malaria control using gene drives was selected as the focal issue, and the course followed a structured decision-making process. Sixty-three sixth-grade students participated in the study. We analysed the students' decision-making arguments to explore their trade-off practices. To examine how students addressed the risk-benefit tradeoffs, we examined four components: rationale of the position, rebuttal to the risks or benefits, weighting of the risks or benefits, and risk mitigations of using or not using gene drives. While the students' arguments included more components after the instruction unit, some arguments did not incorporate the outcomes of tradeoff reasoning, such as risk mitigations. This suggests room for improvement in the instructional strategies of the unit.

Keywords: Socioscientific issues, decision-making, tradeoff, primary school students, instructions

INTRODUCTION

Making science-informed decisions and participating in public debates are vital skills and important learning objectives in science teaching (Jimenez & Zwickle, 2024). Decision-making about complex socioscientific issues (SSIs) involves recognising and balancing tradeoffs among conflicting values. The structured decision-making (SDM) process includes seven steps that support students' in resolving SSIs: 1. define the problem, 2. objectives, 3. alternatives, 4. information, 5. analysis, 6. choice, and 7. review (Dauer, Sorensen, & Jimenez, 2022; Jimenez et al., 2024). In step 5, students evaluate each alternative based on the objectives identified, a process known as tradeoff optimisation. Jimenez et al. (2024) defined three features of trade-off practices and explored students' tradeoff practices in a science literacy and decision-making course. Several science education studies have classified higher quality tradeoffs as those that employ compensatory strategies (e.g. Fang, Hsu, & Lin, 2019). A compensatory strategy presents the notion of weighing the tradeoffs, unlike a non-compensatory strategy where only one criterion is considered at a time (cut-off).

A number of SSI-based instruction units have been developed for junior high and high school students, college students, and pre-service teachers. However, there is a lack of empirical research using quantitative data on primary school students' socioscientific decision-making. To address this, we developed SSI-based instruction units for primary school students, emphasising on decision-making and evaluating the risks and benefits of several scientific technologies. Our recent study evaluated the educational outcomes of an instruction unit that deals with the development and marketing of genome-edited fish. The analysis revealed that, although the intervention enabled fifth graders to make evidence-based decisions, students continued to favour risk-averse choices, exhibiting a zero-risk orientation even after the intervention (Sakamoto et al., 2023). This could be due to the influence of food-specific risk perception or by the complexity of the SSIs presented, which may have been challenging for students to fully engage with.

Based on these findings, we developed a new instructional unit focused on genome editing unrelated to food. It includes learning activities that make learners consider the risk-benefit tradeoff and the trade-off between the risks of using or not using genome editing. In the present study, we analysed the decision-making arguments of primary school students to explore their tradeoff practices, particularly how they dealt with the risk-benefit trade-off and justified their decisions.

METHODOLOGY

Participants

Sixty-three students (33 girls and 30 boys) in the sixth grade (11–12 years of age) from two classes at a national university-affiliated primary school in the Kansai region participated. All students were Japanese and came from a middle-class socioeconomic background. Approximately six months prior, they had experienced SSI-based units for genome-edited fish. The students' regular science teacher, who has been teaching science for nearly 17 years and has some experience with SSI-based instruction, taught the curriculum.

Instruction unit

The goal of the instruction unit was to have primary school students make informed decisions through tradeoff practice, where they compared and weighed the benefits and risks of the novel technology. We selected malaria control using gene drives as the focal issue and conducted collaborative sessions to discuss this topic.

The instruction unit was conducted in Japanese, the language of instruction for students. It consisted of 15 lessons, each 45 minutes long, and followed the principles of the structured decision-making process. At the beginning of the unit, the students learned about malaria, its incidence, current malaria control strategies and those limitations. They were informed of new control strategies using gene drives. Public decision-making regarding genome editing to control malaria was set as an objective of the unit (SDM steps 1-3).

In the next phase, students learned about the benefits and risks of using the gene drives, as outlined in Table 1. Four categories of benefits and risks were presented, reflecting both supporting and opposing opinions on the focal issue (SDM step 4). Students then made their first and preliminary decisions. Students then made their first, preliminary decisions, explaining their reasoning and indicating the extent to which they considered the risks and benefits (SDM steps 5–6). This was followed by step 7, where students reviewed the arguments of their decisions, both individually and in groups.

Then, students attended the second decision-making session. The teacher clarified the risks and benefits of not using the gene drive, essentially continuing with the current malaria control strategies.

This was then followed by a lecture on crafting persuasive decision-making arguments, explaining that the persuasiveness of an argument can be strengthened by clearly listing the benefits, risks, and the potential risks of inaction, while emphasizing one of these points. Students then made their second and final decisions (second SDM session, steps 5–6).

Benefits of using the gene drive	Risks of using the gene drive
Disease:	Ecosystems:
Will eliminate infection with malaria.	May affect ecosystems.
Environment:	Animal ethics:
Less environmental impact than current strategies.	Not everything can be done to animals.
Cost:	Cost:
Less costly than current strategies.	Doubtful that the benefits will be worth the cost.
Technology applications:	Misuse of the technology:
Can be applied to the eradication of other infectious	This technology could be used for the purpose of
diseases and extermination of invasive species.	harming people or nature.

Table 1. Overview of the benefits and the risks presented to the students

Data collection and analysis

Students' written arguments in the first and the second decision-making sessions, i.e. step 6, were collected for analysis. In coding students' written arguments, we divided them into various components in terms of argumentative structure and the outcome of tradeoff reasoning. The components we focused on were: rationale of the position (i.e. presented risks or benefits of using the gene drive, as shown in Table 1), rebuttal to the risks or benefits, weighting of the risks or benefits, and risk mitigations for using gene drives or alternatives to not using gene drives. Weighting statements, risk mitigations, and alternative solutions were established as indicators of students' trade-off reasoning. Examples of students' descriptions of each component are presented in Table 2.

	Table 2. Examples of students' descriptions
Components	Examples
Rebuttal	- The use of insecticides may become more effective and less expensive, but while they may cost
	less, they may also pose health risks. Moreover, we do not know whether they are really effective.
	- I think it is pointless to talk about potential risks to ecosystems now, because we have already
	changed various ecosystems. Secondly, regarding costs, I do not think we have enough time to think
	about whether the effects will be worth it or not.
Weighting	- The following risks are associated with the use of gene drives to combat malaria (omitted).
	I considered the risks of using gene drives to be acceptable. The reasons for this are (omitted).
	- There are also risks in not using gene drives. For example, the use of insecticides has a negative
	impact on the natural environment. However, I am against their use because the risk of gene drives
	destroying the ecosystem is greater.
Risk	- Restricting places where they are used.
mitigations	- Governments should set regulations to prevent misuse of the technology.
	- Releasing genome-edited mosquitoes that do not carry the malaria parasites, instead of mosquitoes
	with sterility genes.
	- It should be used initially in some areas and then over a wider area.
Alternative	- The risks associated with not using gene drives would be eliminated if pesticides were improved
solutions	with state-of-the-art science.
	- I think it would be more effective to spend money on current strategies and continue them.

Table 2. Examples of students' descriptions

RESULTS AND DISCUSSIONS

Table 3 presents the mean values for each component described in the first and second decisionmaking sessions. The number of rationales, weighting statements, rebuttals to the risks, and implications of risk mitigations increased from the first to the second session. In the subsequent analysis, we focused on data from the second session, which contained a certain number of statements.

In the second decision-making session, the rationales mentioned with the most frequently mentioned were the risk to the ecosystem (88.1 %), misuse of the technology (59.3 %), and the benefit of reducing disease, specifically malaria transmission (78.0 %). Statements weighing the risks to the ecosystem (20.3 %) and mitigations for the possible risks to the ecosystem and misuse (18.6 % and 20.3 %, respectively) were frequently described. These results indicate that some risks were barely mentioned.

Components	1st Decision-making		2nd Decision-making		t	р
Presented risks	1.59	(0.97)	2.14	(1.09)	3.672	p<.001
Presented benefits	0.93	(1.00)	1.46	(1.06)	3.301	<i>p</i> <.01
Rebuttal to risks	0.02	(0.13)	0.19	(0.54)	2.621	<i>p</i> <.05
Rebuttal to benefits	0.14	(0.39)	0.02	(0.13)	-2.176	<i>p</i> <.05
Risk-weighted statements	0.03	(0.18)	0.42	(0.65)	4.652	<i>p</i> <.001
Benefits-weighted statements	0.00	(0.00)	0.15	(0.36)	3.231	<i>p</i> <.01
Risk mitigations or alternative solutions	0.47	(0.82)	0.75	(0.88)	2.348	p<.05

Table 3. Means and standard deviations of components written in students' decision-making arguments. (N=59)

The percentage of students in favour of gene drive use, indicated in each decision-making session, was 26.7 % in the first session and 31.7 % in the second session, with most respondents opposing both. The percentage of students who described each component in the second decision-making session's argument was calculated by position (Table 4). A comparison of the appearance rates between positions revealed significant differences in some components. Students in favour weighted the benefits and described more rebuttals to risks and risk mitigations, whereas students against weighted the risks and described marginally more alternative solutions.

In the second decision-making arguments by positions					
Components	Students in favour	Students against	χ^2	р	
Presented risks	89.5	97.5	1.719	<i>n.s.</i>	
Presented benefits	94.7	77.5	2.719	n.s.	
Rebuttal to risks	31.6	5.0	7.764	<i>p</i> <.01	
Rebuttal to benefits	0.0	2.5	0.483	n.s.	
Risk-weighted statements	0.0	50.0	14.372	<i>p</i> <.001	
Benefits-weighted statements	47.4	0.0	22.358	<i>p</i> <.001	
Risk mitigations	52.6	27.5	3.549	<i>p</i> <.10	
Alternative solutions	5.3	25.0	3.308	p<.10	

Table 4. Percentage of students who described each component in the second decision-making arguments by positions

Note: N=59. Gothic figures indicate components with significantly more occurrences.

CONCLUSIONS

The goal of the instruction unit developed in this study was to have primary school students make informed decisions through tradeoff practice, in which they compared and weighed the benefits and risks of the novel technology. This enhanced the students' ability to make informed SSI decisions. After the unit, students' decision-making arguments included more components, such as the rationale of the position. Most students described both risks and benefits in justifying their positions. However, only approximately half of the students made weighting statements or suggested risk mitigations to reap the benefits of the technology, as outcomes of tradeoff reasoning. The remaining students may have used non-compensatory strategies (cut-offs). These results do not indicate that the unit's instructional goals were fully achieved. There is still room for improvement in the instructional strategies adapted to this instruction unit.

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EXPLORING AN EDUCATIONAL TOOL FOR PROMOTING AN INTEREST AMONG PUBLIC WITH BIODIVERSITY CONSERVATION: EFFECTS AND CHALLENGES OF QR CODE QUIZZES AT A ZOO

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ABSTRACT

Disseminating the idea of biodiversity to the public for creating a sustainable natural environment is a global challenge. Research on how zoos can be used to promote knowledge about biodiversity among the public is limited. This study aimed to examine the effectiveness of QR code quizzes focusing on invasive species at Tennoji Zoo in Japan. The quiz was conducted for 1 month, and 516 visitors participated in the quiz event. Findings revealed that the QR code quizzes 1) stimulated the interest of and engagement among a wide range of age groups from children to adults; 2) contributed to raising awareness of the existence of native and non-native species; and 3) increased people's motivation to learn about living things. The quizzes were able to effectively achieve the goals of stimulating interest in the issues raised and disseminating knowledge about the existence of native and non-native species in Japan.

Keywords: biodiversity education, Japanese zoo, public communication, QR code quizzes

INTRODUCTION

Creating awareness of biodiversity among the public to develop a sustainable natural environment is a challenge worldwide (UNESCO, 2017). To accomplish this objective, it is important to accumulate knowledge of the methods and content that are effective for the general public as a part of science education research. So far, zoos have been focused on as places where the public can learn about biodiversity issues (Dove & Byrne, 2014; Chalmin-Pui & Perkins, 2017). However, few studies have examined the effectiveness of educational tools to promote biodiversity knowledge among the public at zoos. Therefore, this study aimed to address this gap in the extant literature. Increasing educational research about zoos would be a logical step towards addressing the issue of how to spread an understanding of biodiversity throughout society and how to help people develop better ethical attitudes towards biodiversity conservation. For example, the current situation and problems of red-eared sliders (reproduction in the wild due to the abandonment of captives) in Japan are discussed in zoos through videos and picture cards, and the issue of mongooses preying on native species is presented through a picture storybook (The Ministry of the Environment, 2024).

RESEARCH FOCUS AND QUESTIONS

A perspective on biodiversity conservation education in Japan: native and invasive species

Japan implemented the Act on the Prevention of Adverse Ecological Impacts Caused by Designated Invasive Alien Species in 2004. The Ministry of the Environment (2024) is promoting the dissemination of easy-to-understand educational materials on the conservation of native

species (including endemic species) and issues pertaining to invasive species to raise awareness among professionals who work with animals as well as the public.

In recent years, exotic animals, such as amphibians and reptiles, have become popular as pets in Japan. Amid this exotic animal boom, releasing pets into the wild when people can no longer keep them has emerged as a critical biodiversity problem.

RESEARCH QUESTIONS

This study addressed the following two points.

RQ1. What are the advantages and disadvantages of organising QR code quizzes at zoos? RQ2. How can QR code quizzes increase interest among the public in the issues related to native and invasive species?

The authors collaborated with Tennoji Zoo in Osaka to develop and implement educational materials related to biodiversity conservation for visitors (Miyake, 2024). Educational materials, such as picture storybooks, animated videos, and face-to-face quizzes were developed for zoo visitors and their effectiveness verified. In this study, QR codes, a contactless tool that became increasingly popular after the COVID-19 pandemic in 2019, were used as an alternative educational tool. The content was designed to raise awareness of issues regarding native and invasive species as part of biodiversity conservation education.

METHODOLOGY

Development of QR code quizzes

Six QR code quizzes that focused on the issue of invasive species were designed. Six amphibians and reptile species were selected to serve as motifs for the quizzes. The non-native species included *Macrochelys temminckii* (alligator snapping turtle), *Iguana iguana* (green iguana), and *Xenopus laevis* (African clawed frog). The native species included *Mauremys japonica* (Japanese pond turtle), *Andrias japonica* (Japanese giant salamander), and *Bufo torrenticola* (Japanese stream toad).

QR codes were displayed next to the animal exhibited along with explanations (Figure 1). For example, in the case of the giant salamander, an explanatory text (Table 1) was presented next to the animal's tank. When visitors scanned the QR code on their mobile phones, a quiz appeared on the phone screen. The quiz for each animal included two multiple choice questions and an open-ended question (Table 2). After each of the six animal quizzes, a summary quiz on native and invasive species was displayed (Table 3).



Figure 1. How the QR code quiz was presented to the participants

Table 1. An explanatory text on the Japanese giant salamander

I'm a giant salamander, a rare creature that only exists in Japan. I've had the same appearance for about 3,000 years; therefore, I'm called a living fossil. I'm a national 'special natural monument'. I live in a cold mountain river, but recently the riverbank has become hardened with concrete, which has eliminated the small creatures that served as food for me. This has caused my eggs to be released into the sea, resulting in a decrease in the number of my species. In addition, hybridisation with the closely related Chinese giant salamander is progressing, resulting in the decline of endemic species found only in Japan.

Table 2. Quizzes on the Japanese giant salamander

Q1. Where do I (the giant salamander) live?
a) A cold mountain river water, b) Grassland, c) Warm sea water
Ω^2 The giant salamander is a Japanese XX species. Which of the below options is XX?
a) Endemic b) Specified c) Invasive
a) Endemic, b) Speenled, c) invasive
Q3. Why is the number of this species decreasing? (open-ended question)
Table 3. Summary Quizzes
O1. Which of the following is a native species?
a) Green iguana h) Giant salamander, a) Flowing toad d) African alawad frog
a) Green iguana, b) Grant salamander, c) Flowing toad, d) Antean elawed nog,
Q2. What is the best way to protect native species from invasive species? Choose a phrase to
replace the brackets.
' 'Don't let invasive species into the land () don't spread them'
a) Dan't crue there is Dan't there is the mean of Dan't terral them
a) Don't own them, b) Don't throw them away, c) Don't touch them
Q3. What should you not do if you can no longer keep your pet?
a) Release them into the wild, b) Give it to someone who will take care of it. c) Consult with
monofactionals
protessionais

Q4. What efforts can you make for native species? (open-ended question)

Implementation period

The development period for the quiz was eight months between May and December 2023, and it was conducted for one month at the zoo in January 2024. During the study period, an interactive event was organised at the zoo on 2nd January 2024 as a New Year's event. The QR code quizzes were intended to encourage the voluntary participation and spontaneous engagement of zoo visitors.

RESULTS AND DISCUSSIONS

A total of 516 participants took part in the study of which 290 (56%) were elementary school students, 51 (24%) were university students or older (adults), 10 (10%) were younger than elementary school children, and 9 (10%) were secondary school students. The number of responses to the quizzes for each of the six species and the summary quiz are shown in Table 4.

Table 4. Number of responses				
Species	Number of responses			
African clawed frog	75			
Japanese stream toad	65			
Green iguana	65			
Alligator snapping turtle	79			
Japanese pond turtle	67			
Japanese giant salamander	67			
Summary quiz	50			

The majority of participants (n=79) were interested in alligator snapping turtles. One possible reason for this is that the turtle has a striking appearance, and the exhibition tank is so large that it exceeds the height of a human; therefore, people may have been drawn to the quiz posted next to the tank. Among the multiple-choice questions, the one with the lowest correct answer rate was regarding the habitat of the green iguana. The correct answer was Mexico, but 8 people (12%) chose South Africa. Many Japanese people believe that green iguanas live in warm places, and South Africa includes the name of a region in Africa which is associated with warm climate; therefore, many people gave this response.

Meanwhile, the responses to the open-ended description in the summary quiz were as follows:

- I enjoyed the easy-to-understand explanations and adorable illustrations. I did not know many things, so I learned a lot. (62 years old)
- I had a lot of fun learning. (8 years old, 9 years old, 31 years old, 27 years old)
- It was difficult/very difficult. (4 years old, 10 years old)
- I was able to learn many things. (10 years old), and I wanted to try other challenges. (10 years old)
- I walked around the animal exhibits several times to complete all the questions. (27 years old)

A wide age group ranging from 4–62 years old completed the quizzes. It is evident that the quiz attracted the interest of a wide range of people regardless of their age.

CONCLUSIONS

This study aimed to examine the efficacy of QR code quizzes to promote biodiversity conservation knowledge among the Japanese public. The findings indicated three main advantages of the quizzes, that is, they 1) stimulated the interest of and engagement among a wide range of age groups from children to adults; 2) contributed to raising the awareness of the existence of native and non-native species; and 3) increased people's motivation to learn about living things. However, the results revealed certain limitations of these quizzes. For example, it was difficult to understand the content of an individual participant's learning process.

Overall, the QR code quizzes achieved the goals of stimulating interest in the issues highlighted and disseminating knowledge about the existence of native and non-native species in Japan. By incorporating such educational tools, people's awareness of zoos may change from merely being a place to see and enjoy animals to a place where they can gain interest in animals and feel motivated to know more about them. These study findings have important implications for researchers in science education.

Acknowledgement

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SCAFFOLDING PRIMARY SCHOOL STUDENTS' TRADEOFF PRACTICES BETWEEN RISKS AND BENEFITS IN SOCIOSCIENTIFIC DECISION-MAKING

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ABSTRACT

This study investigated the learning activity of comparing the risks of using and the risks of not using gene drives for malaria control, which might scaffold primary school students' tradeoff practices between the risks and benefits of using gene drives in their decision-making. Twenty-two students were interviewed to investigate how they weighed the risks and benefits in their decision-making processes before and after the learning activity. The findings indicate that the learning activity can potentially scaffold students' tradeoff practices. In their decision-making before the learning activity, students predominantly focused on the risks rather than the benefits, preventing them from weighing the risks and benefits. However, during the learning activity, students came to recognise that the benefits of using gene drives are not available if the current malaria control strategies continue to be used. Consequently, students could weigh the risks and benefits in their decision-making after the learning activity.

Keywords: Socioscientific issues, decision-making, tradeoff, primary school students, scaffolding

INTRODUCTION

One of the key goals of science education is to enhance students' ability to make decisions about controversial socioscientific issues (SSIs) that they will face as citizens in the future (Zeidler & Sadler, 2023). SSIs are multifaceted and complex problems that involve scientific, technical, economic, ethical, and social aspects. Consequently, appropriate decision-making for solving such problems requires high-level tradeoff practices to evaluate the conflicting advantages and disadvantages of multiple solutions (Jimenez et al., 2024). For example, in the context of advanced technologies like genetic engineering, it is necessary to engage in the process of weighing the risks and benefits of using advanced technologies.

Such tradeoff practices are challenging. Previous research has shown that students tend to avoid engaging in complex tradeoff practices (Gregory, 2002). Furthermore, it has been observed that students tend to use non-compensatory strategies to avoid cognitively demanding compensatory strategies (Gresch et al., 2013). It is, therefore, evident that students need appropriate instruction to engage in tradeoff practices. However, there is a lack of existing research on the instruction of students in tradeoff practices, and further research is needed to address this gap in the literature. Furthermore, previous research has been conducted with undergraduate and secondary school students but not with primary school students, despite the need for SSIs-based instruction at a younger age (Kahn, 2020). Investigating the teaching of tradeoff practices with primary school students is expected to provide new insights into SSI decision-making while contributing to the existing body of knowledge on SSI-based instruction with primary school students.

We developed a socioscientific issue-based instructional unit to scaffold primary school students' tradeoff practices between the risks and benefits of using gene drives for malaria control in socioscientific decision-making (Sakamoto et al., 2024). In addition, we conducted analyses of students' written arguments in the unit. It was clear that the unit enabled students to weigh the

risks and benefits in their decision-making. However, the specific learning activities within the unit that scaffold students' tradeoff practices remain unknown.

Consequently, this study focuses on the learning activity of comparing the risks of using and not using gene drives for malaria control, with the aim of investigating how this learning activity might scaffold students' tradeoff practices between the risks and benefits of using gene drives by analysing students' responses to the post-interviews.

METHODS

Participants

The study was conducted with the participation of sixty-three (63) sixth-grade primary school students between the ages of eleven and twelve. All the students were Japanese and came from middle-class backgrounds. A teacher who regularly taught the students was also involved in the study. The teacher had nearly seventeen years of experience teaching at the primary level and almost six years of experience teaching SSI-based instructional units.

Instruction Unit and Learning Activity

The unit was conducted in Japanese, the language in which the students and teacher used regularly. It consisted of fifteen lessons of forty-five minutes each. In the first half of the unit, students learnt basic knowledge about malaria, current malaria control strategies, and gene drives. Students then learnt the risks and benefits of using gene drives for malaria control.

In the latter part of the unit, students engaged in socioscientific decision-making. Each student was required to take a position, either for or against the use of gene drives for malaria control, and to write an argument outlining the reasons and rationale for their decision (first decision-making). Students were then engaged in the learning activity to compare the risks of using the gene drives for malaria control with the risks of not using them. Students then reviewed the learning material used in the first half of the unit and presented the risks of not using the gene drives to the class. The risks identified by the students were as follows: (a) current malaria control strategies (bed nets, prophylactics, vaccines and insecticides) are not effective enough to prevent people from dying from malaria control strategies continue to be used, (c) the use of insecticides in current malaria control strategies will continue to have adverse effects on humans and the environment, and (d) malaria cannot be eradicated, so the possibility of future malaria epidemics in Japan will remain. The students were then asked to make a decision again, either for or against the use of gene drives for malaria control. They were then asked to write an argument outlining the reasons and rationale for their decision (second decision-making).

Data Collection and Analysis

Post-interviews were conducted to investigate whether the learning activity, which compared the risks of using and the risks of not using gene drives, could effectively scaffold students' tradeoff practices between the risks and benefits of using gene drives for malaria control. Following the case study method (Yin, 2018) and the approach taken in previous research on socioscientific decision-making (Sadler & Zeidler, 2005), the students were selected to serve as cases for the purposes of the interview. Twenty-seven students who had not considered the tradeoffs in the first decision-making but had done so in the second were identified. Twenty-two of these students were randomly selected and interviewed. The interviews explored the students' decision-making processes, specifically how they weighed the risks and benefits in their first and second decision-making.

FINDINGS

Table 1 shows examples of students' responses in the post-interviews. Student #102 took a position against the use of gene drives for malaria control in the first and second decisions. In the first decision-making, the student thought that the benefits were not significant because he only considered the risks of using gene drives. The student then reassessed the benefits of using gene drives through the learning activity. As a result, student #102 stated that he realised that it is necessary to weigh the benefits as well as the risks of using gene drives in the second decision-making.

Similarly, student #218 also took a position against using gene drives for malaria control in the first and second decision-making. The student stated that by comparing the risks of using and the risks of not using gene drives in the learning activity, she reaffirmed the material she had learnt in the first half of the instructional unit. The student mentioned that the review made her realise that many young children had died under the current malaria control strategies. As a result, the student stated that she was struggling with whether the gene drive should or should not be used for malaria control in the second decision-making.

Student #226 took a position for using gene drives for malaria control in the first and second decision-making. The student stated that the learning activity confirmed the content of the material learnt in the first half of the instructional unit by comparing risk to risk. Through this confirmation, the student mentioned that he thought the risks of not using the gene drives should be weighed heavily. He also mentioned the benefits of using gene drives should also be weighed heavily due to the current reality that more people are dying without the use of gene drives.

Table 1. Examples of students' responses in post-interviews

Student #102
(The student took a position against using gene drives in the first and second decision-making.)
In the first decision-making, I was only thinking about the risks of using gene drives, so the benefits were not important to us. However, after considering the risks of not using gene drives, I looked again at the benefits of using gene drives, and I thought that the benefits were indeed important.
There are risks to using the gene drives, but I also thought that the benefits of using it were essential because it would be wrong for people to die.
Student #218
(The student took a position against using gene drives in the first and second decision-making.)
Some people are suffering a lot from malaria because the gene drives are not used, and if the gene drives are not used, a lot more people will get malaria. At the moment, more than 600,000 people have died, so it is acceptable to use gene drives as many more people could die. When I looked back at all the learning material in the first half of the instructional unit and thought again about the deaths of young children, I felt that the risks of not using the gene drives would also become more critical.

Student #226

(The student took a position for using gene drives in the first and second decision-making.)

There may be ways to control malaria that do not involve gene drives. However, after reviewing the material we learnt in the first half of the unit, I was struck by the episodes of the failure to save the life of a baby infected with malaria. It would be good if we could prevent people from getting malaria. Nothing will change the current situation that more people die without gene drives. We need to focus on the risks of not using gene drives and recognise again that we should focus on the benefits of using them.

CONCLUSIONS AND FUTURE WORKS

The findings of this study indicate that the learning activity of comparing the risks of using and the risks of not using gene drives can potentially scaffold students' tradeoff practices between the risks and benefits of using gene drives. In their decision-making before the learning activity, students predominantly focused on the risks rather than the benefits, thereby preventing them from weighing the risks and benefits. However, during the learning activity, students came to recognise that the benefits of using gene drives are not available if the current malaria control strategies

continue to be used. Consequently, students were able to weigh the risks and benefits in their decision-making after the learning activity.

Future work is required to enhance scaffolding. Approximately half of all primary school students who participated in this study were unable to weigh the risks and benefits, even after learning in the instructional unit. The current scaffolding in the unit needs to be improved for these students, and additional scaffolding is considered necessary. Further data analysis is required to determine what additional scaffolding is needed to enable them to engage in tradeoff practices in socioscientific decision-making.

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THE EFFECTS OF ARGUMENT-BASED TEACHING STRATEGIES ON PROMOTING UNDERSTANDING OF THE NATURE OF SCIENCE: FOCUSING ON THE RELATIONSHIP WITH THE QUALITY OF THE ARGUMENT

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ABSTRACT

The purpose of this study was to introduce the teaching strategies proposed by the Argument-Driven Inquiry project into Japanese science classrooms, and to clarify the relationship between students' understanding of the nature of science and their ability to construct arguments. We conducted an experimental lesson that incorporated the four teaching strategies of the ADI project. The evaluation result indicated that students who achieved a high level of argument tasks also showed a significant improvement in their understanding of the nature of science. Based on the findings, we conclude that there is a notable relationship between the achievement of the argument and the understanding of the nature of science.

Keywords: nature of science, argument, teaching strategies, argument-driven inquiry project

INTRODUCTION

In science education, the importance of engaging students in argument construction has been pointed out as a strategy for promoting students' understanding of the nature of science (McDonald, 2017). The nature of science is defined as perceptions about science, science as a way of knowing, or values and beliefs about scientific knowledge and its development (Lederman, 1992). It has been noted that the construction of an argument is an authentic scientific practice in which scientists engage in theory building, and that having students experience this process promotes their understanding of the nature of science (McDonald & McRobbie, 2012).

One of the most well-known argument-based education projects is the Argument-Driven Inquiry project (hereinafter "ADI project") led by Victor Sampson (e.g., Walker and Sampson, 2013). This project, which aims to achieve the Next Generation Science Standards (NGSS, Lead States, 2013), provides insights for introducing arguments into the classroom. In addition, the project includes new perspectives such as anonymous peer review activities for arguments and community acknowledgement of knowledge. Previous research has shown that the ADI project is effective in promoting conceptual change (e.g., Cetin et al., 2018) and improving their skills in constructing arguments (e.g., Sampson & Walker, 2012).

However, previous research has not clarified the effectiveness of the ADI project in promoting students' understanding of the nature of science. The purpose of this study was to introduce the teaching strategies proposed by the ADI project into Japanese science classes, and to clarify the relationship between students' understanding of the nature of science and their achievement in argument construction.

METHODOLOGY

First, this study organized the teaching strategies of the ADI Project into four categories, referring to Sampson et al. (2021). The first strategy is to lecture students about the components of an argument and how to construct one (hereinafter "Lecture"). The second is to have students critique each other's arguments (hereinafter "Critique"). The third is to have students anonymously evaluate each other's reports, which allows them to experience the authentic activities of scientists

(hereinafter "Peer review"). The fourth is to deepen their understanding of the practice of science connecting the activities that the students have been engaged in with the practices in which scientists have engaged

(hereinafter "Connection").

TABLE 1. Outline of experimental classes and leaching strategies reflected in the classes	Table 1.	Outline of	f experimental	classes and	teaching str	ategies re	eflected in th	e classes
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Period	Overview of experimental classes	Teaching strategies
1	Introduction to the unit Setting up the task through an introductory experiment	
2-4	<u>Activities about combustion and air movement</u> Conducting Experiment A (about combustion with and without air passage) Introducing arguments and writing arguments about Experiment A	Lecture
5-7	Activities about combustion and gases Conducting Experiment B (on the auxiliary combustibility of gases) Writing, sharing and critiquing arguments on Experiment B	Critique
8-9	<u>Activities about combustion and air changes</u> Conducting Experiment C (about the percentage of gas changes before and after combustion) Writing, sharing, and critiquing arguments about Experiment C	Critique
10-13	<u>Report writing, evaluation, and revision</u> Report writing on the developmental content of Experiment C Peer review of prepared reports	Peer review
14-15	<u>Unit conclusion</u> Consider the connection between the students' activity and the scientist's activity	Connection

Next, we conducted an experimental class. This class was for 52 sixth-grade Japanese elementary school students. The topic was the mechanism of combustion. Table 1 shows the outline of the class, and the teaching strategies reflected in the class.

Two evaluations were conducted in this study. The first evaluation was a test to measure argument construction skills. The task was to have the students write an argument consisting of a claim, evidence, and reasoning. The subject matter was the same as in the experimental class: the mechanism of combustion. The task was to introduce two different ways of stacking firewood (one with no gaps and one with gaps to allow air to pass through), and to ask which method would burn more strongly. The task was conducted at the end of the experimental class and took 10 minutes to complete. For the scientific explanations written by the students, we identified the statements that made claims, provided evidence, and provided reasoning, and scored them out of 2 points each (total of 6 points) based on the validity of their content.

The second evaluation was a questionnaire measuring students' understanding of the nature of science. The questionnaire consisted of 20 items covering three aspects: creativity (6 items), tentativeness (9 items), and consistency (5 items), based on Chen et al. (2013). For example, a creativity item stated, "Scientists need creativity and imagination to conduct experiments." Tentativeness included items like "The currently accepted scientific knowledge may change if better explanations are provided." Consistency included items like "If the same experimental method is used, the results should be the same regardless of where the experiment is conducted."

For each item of the questionnaire, students were asked to choose from "strongly agree," "somewhat agree," "neither agree nor disagree," "not strongly agree," or "not at all agree. The survey was administered twice, just before and just after the start of the experimental class and 15 minutes to complete. When analysing the data, the average score for each were calculated - consistency, creativity, tentativeness where "strongly agree" given a score of 5 and "strongly

disagree" given a score of 1. The Wilcoxon signed-rank test was then used to assess any statistically significant changes in the average scores for each item before and after the class.

Table 2. Score distributionfor claim, evidence and reasoning				
	0	1	2	
Claim	6	14	32	
Evidence	4	12	36	
Reasoning	3	3	46	
note, $n=52$				

RESULTS AND DISCUSSIONS

Table 2 shows the score distribution for claim, evidence and reasoning. Each element is scored with a maximum of 2 points. For the claim, 32 students scored the maximum of 2 points. For the evidence, 36 students scored the maximum of 2 points. For the reasoning, 46 students, the majority, scored the maximum of 2 points. When the scores for claim, evidence and reasoning are totalled and counted as a maximum of 6 points, the average score is 4.94 points.

When the group that scored above the average was labelled as the "high-scoring group" and the group that scored below the average was labelled as the "low-scoring group", the high-scoring group consisted of 42 students and the low-scoring group consisted of 10 students. First, we will explain the results regarding consistency within the nature of science. Before the class, the average score for the high-level group was 3.00 and the average score for the low-level group was 3.07, with no significant difference was found in the average score for the low-level group was 3.76. The Mann–Whitney U test was used to examine whether there was a difference in scores between the groups, and a significant difference in scores was found (z = -3.65, p < .05).

Next, we will explain the results regarding creativity in science. Before the class, the average score for the high group was 3.77 and for the low group it was 3.84, with no significant difference was found in the average score. After the class, the average score for the high group was 4.12 and for the low group it was 3.86. The Mann–Whitney U test was used to examine whether there was a difference in scores between the groups, and a marginally significant was found (z = -1.73, p < .10).

Finally, we will explain the results regarding the tentativeness of science. Before the class, the average score for the high group was 4.01 and the average score for the low group was 3.88, with no significant difference observed. In contrast, after the class, the average score for the high group was 4.35 and the average score for the low group was 3.87. The Mann–Whitney U test was used to examine whether there was a difference in scores between the groups, and a significant difference was found (z = -3.30, p < .05).

From these results, it appears that students who developed strong argument construction skills through the experimental class gained a deeper understanding of the components of the nature of science, namely - consistency, creativity, and tentativeness, compared to students who did not.

CONCLUSION

The purpose of this study was to introduce the teaching strategies proposed by the ADI project into Japanese science classes, and to clarify the relationship between students' understanding of the nature of science and their achievement of arguments. The evaluation results showed that students who achieved a high level of argument task also showed a significant improvement in their

understanding of the nature of science. From this, we conclude that there is a clear relationship between success in argument tasks and an enhanced understanding of the nature of science.

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EVALUATION OF A JAPANESE ELEMENTARY SCHOOL CLASS USING SIMULATORS AND ARGUMENTS TO PROMOTE SCIENTIFIC DECISIONS ON FOOD POISONING PREVENTION REGARDING PUFFERFISH-TOXIN

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ABSTRACT

It has been indicated that measures to prevent food poisoning due to bioaccumulation of harmful substances need to be improved. Consumers must acquire the ability to make scientific judgements, based on their knowledge of how bioaccumulation occurs. This study develops and evaluates a class to promote decisions according to scientific judgement, regarding prevention of food poisoning, based on the mechanism of bioaccumulation, with focus on pufferfish toxins. Simulators and arguments are used to conduct the study. Elementary school students learned the mechanism of bioaccumulation of toxins in pufferfish through simulations, and they constructed arguments consisting of "claim - evidence – reasoning," in the class. The analysis of worksheets and arguments showed that most students were able to make scientific judgements while utilizing the mechanism of bioaccumulation of toxins in pufferfish. Based on the findings, building support to encourage correct reasoning was suggested.

Keywords: Computer Simulation, Argument, Food Chain, Bioaccumulation, Scientific Decisions

INTRODUCTION

Preventing food poisoning due to bioaccumulation of toxic substances requires scientific judgement and knowledge of the mechanism of bioaccumulation (Sharif & Al-Malki, 2010). One specific example constitutes the safety decision regarding the consumption of pufferfish. This practice requires a scientific understanding of the bioaccumulation of pufferfish toxins and a scientific judgement on the safety of consuming pufferfish (Ito et al., 2022).

To develop a scientific understanding of the bioaccumulation of pufferfish toxins, it is important for students to learn the process through observation and experimentation. However, the bioaccumulation of pufferfish toxins is complex, widespread, and long-term, making it difficult to observe directly. Simulations are effective for such learning (Yamaguchi et al., 2010). Matsuyama et al. (2023) developed simulators to understand the bioaccumulation of pufferfish toxins and revealed their applications.

Furthermore, to make scientific judgements about the safety of pufferfish consumption, it is important to develop the ability to evaluate the validity of the ideas or claims held while examining experimental results (Erduran & Jiménez-Aleixandre, 2007). The adoption of "argument", a tool to support scientific argumentation and decision-making, has been used in many teaching methods in recent years, as it effectively promotes the development of these skills (Muratsu et al., 2015).

Therefore, this study aimed to (i) develop a class to encourage students to make decisions regarding prevention of food poisoning based on scientific evidence of the mechanism of bioaccumulation of pufferfish toxins by using four different simulators (A, B, C, and D) as

developed by Matsuyama et al. (2023), and the argument made up of claim-evidence-reasoning (scientific principle), and (ii) evaluate its effectiveness.

METHODOLOGY

Overview of the Class

The class was conducted over two hours in July 2023 (three scenes) with 43 sixth grader (aged 11-12) in a science unit called, "The links between living things and living creatures". The students had already learned about food chains on land and in rice paddies. This class focused on the presence and absence of toxins accumulated in the body of the pufferfish which feeds on four creatures: marine bacteria (toxin-producing creatures), clams, crabs and starfish. The students were asked, "Are the pufferfish that do not consume marine bacteria, not poisonous?". Using simulator A in Scene-1, students were asked to understand the food chain mechanism in the five creatures.

Meanwhile, simulators B and C were used in Scene-2 to help the students understand the basic mechanism of bioaccumulation: "All the toxins in the prey are absorbed by the predator." Simulator D was then used to focus on the more advanced mechanism of toxins being concentrated in greater quantities as they approach higher predators. Simulator D took the number of toxins produced by marine bacteria as one (constant), the number of individual creatures preyed upon by the pufferfish as an independent variable, and the number of toxins transferred from each creature preyed upon by the pufferfish into its body as the dependent variable. Then, the students could let the pufferfish prey on the four creatures while swimming freely, allowing them to investigate the number of toxins accumulated in its body with the different prey types. Students were instructed to develop hypotheses based on the basic mechanisms of bioaccumulation, and to systematically proceed through the simulation to obtain experimental results (evidence) that scientifically supported the answers (claims) to the learning question.

In Scene-3, students were asked to construct an argument consisting of "claim-evidencereasoning." The correct assertion statement was "Even pufferfish that do not eat toxin-producing marine bacteria contain toxins." The appropriate evidence was the data from which the information, "a large amount of toxins also accumulated in the body of pufferfish that did not eat marine bacteria at all" can be read. Finally, in the reasoning section, which is the scientific principle linking claims and evidence, the students were encouraged to write statements that could be read as "all the toxins in the prey's body are transferred to the predator's body" based on the basic mechanism of bioaccumulation studied in Scene-2.

Evaluation of the Class

The class was evaluated from two perspectives, that is, "students' understanding" and "students' judgement." To evaluate "students' understanding", the worksheets completed by the students in Scene-1 and Scene-2 were analysed and scored to assess their understanding of the bioaccumulation mechanism of toxins in pufferfish. Worksheets-1 (Figure 1) used in Scene-1 about the food chain between the five creatures were scored according to a rubric. Here, the score was based on a five-point scale which focused on whether children correctly understood "what organisms prey on and are preyed upon by." Worksheets-2 (Figure. 2) used in Scene-2 on bioaccumulation was also scored based on different rubrics. The focus was on whether the students correctly understood that marine bacteria (producers of toxins), clams (primary consumers), starfish and crabs (secondary consumers) and pufferfish (highest consumers) move up the predator hierarchy in that order and large amounts of toxins accumulate in pufferfish through the food chain, which was scored on a one-point scale.

For "students' judgement," the score was given based on the content of the arguments described by the students in Worksheet-3 (Figure. 3) in Scene-3 and assessment on their judgements about the

presence or absence of toxins in pufferfish. Scores were given to the claims, evidence, and reasoning independently based on another rubric-based three-point scale.



Figure 1: "Eat – be eaten" relationship between five creatures (worksheets-1)

Note: The results of each were recorded as "Eat" is \circ , "Eating or being eaten" is \triangle , "Eatable" is \times . For example, (1) Pufferfish eats crabs. (2) Marine bacteria is eaten by crabs. (3) Starfish eats crabs or is eaten by crabs.



Figure 2: Ecological pyramid between five creatures (worksheets-2)

Note: The illustrations of each creature placed in the right frame are moved to the corresponding location.



Figure 3: Argument regarding the presence or absence of pufferfish-toxin (worksheet-3)

RESULTS

In terms of "students' understanding" of how the food chain works (Figure. 4), 36 out of 43 students (84%) understood correctly, that is, students who scored 5 points. Seven students (16%) received a reduction in marks because their statements regarding one or two creatures were partially incorrect (five students scored 4 points and one student scored 3 points), and one student did not write anything at all (scoring 0 point). In terms of understanding of how bioaccumulation works (Figure. 5), 40 out of 43 students (93%) were able to correctly understand how bioaccumulation works. As for the three students who received a reduction in marks, one student incorrectly classified the rank of starfish, and the other two students did not write anything. They were asked to confirm the correct "eat - eaten" relationship through simultaneous instructions.

In terms of "students' judgement" (Figure. 6), 33 out of 43 (77%) of the students were able to correctly judge the presence or absence of pufferfish toxin (3 points) by applying the mechanism of its bioaccumulation. Of the ten students who received a reduction in marks, eight (19%) demonstrated inadequate reasoning (2 points) and two (5%) showed inadequate evidence and reasoning (1 point). All of these students were able to correctly judge the presence or absence of toxins in pufferfish, but they were unable to make appropriate use of the mechanism of bioaccumulation of pufferfish toxins.



Figure 4: Distribution of students by score for Worksheet-1 on understanding the food chain



Figure 5: Distribution of students by score for Worksheet-2 on understanding the bioaccumulation



Figure 6: Distribution of students by score for Worksheet-3 on argument

Consideration

The results of the analysis of worksheets-1 on "students' understanding" revealed that by using simulator A, the students were able to understand the mechanism of the food chain in general. This simulator was designed to allow students to freely select a creature and use it as a subject to investigate the "eat-eaten" relationship. Therefore, it is assumed that the simulation made it possible to obtain the information they desired. The results of the analysis of worksheets-2 showed that the use of simulators B and C facilitated the understanding of the basic mechanisms of bioaccumulation in almost all the students. These simulators have been designed to visualize invisible toxins and optimize the time scale, so it is assumed that the students were able to observe the behaviour of the creatures and toxins and consider the mechanism, while taking a holistic view of the bioaccumulation of pufferfish toxins. These findings revealed that the use of simulators promotes a scientific understanding of the basic mechanisms of bioaccumulation.

Regarding "students' judgement," the results of the analysis of worksheets-3 showed that almost all students were able to correctly judge the presence or absence of pufferfish toxins based on their scientific understanding of the mechanism of bioaccumulation. However, a descriptive analysis of reasoning revealed that some students were unable to use the basic mechanism appropriately. For this purpose, it is necessary to introduce new teaching materials and learning activities to support argument-construction in students who had no prior experience on it.

CONCLUSIONS

The class developed in this study was effective in helping students understand bioaccumulation through simulators and make scientific judgements while utilizing the mechanism of the bioaccumulation of pufferfish toxin through arguments. However, since some students were found

to use incorrect reasoning, it was suggested that more support to construct appropriate reasoning be given to them.

Acknowledgements

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INVESTIGATING SECONDARY STUDENTS' INTEREST IN S&T FROM AN IDENTITY PERSPECTIVE: INTEREST PATTERNS AND COLLECTIVE IDENTITIES IN A SWEDISH CONTEXT

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ABSTRACT

Historically students' interest in science and technology (S&T) has been researched mostly from gender and age perspective and on a subject level of analysis. The work presented in this study utilised the Swedish quantitative data from a large scale international and comparative research project called "The Relevance of Science Education Second (ROSES) study" to investigate secondary students' interest in S&T on a content level of analysis. National data were collected by a questionnaire in 2020. By making use of the theoretical development pointed out in the literature, the "person-object theory of interest" is used to frame and interpret the results. In this perspective interest is expected to differentiate as interest patterns. Seven such patterns were identified by an explorative factor analysis which points out a direction for future work to investigate students' interest in S&T with a deepen understanding of how learning S&T is influenced by identity formation.

INTRODUCTION

In the science education research field, there is a long-standing literature on students' interest and attitudes towards science and technology (S&T). Lack of relevance in school S&T with consequences for recruitment of future professionals and educating a scientifically literate population have been clearly described (Jenkins, 2006). Differences in interest and attitudes have been shown to be connected with gender and age and many studies are done on a subject level of analysis and not on a content level. Osborne, Simon & Collins (2003) pointed out the need for the field to be more specific and detailed to take the research further. Since the beginning of the 21st century the research field has been more involved with young people's identity formation (Tolstrup Holmegaard et al., 2014). Identity is an important concept for a person's willingness to participate in an activity and should not be regarded as an individual process. Hosek & Soliz (2016) described the importance of collective identities and point out that they have not been well described in research literature. Hence, young people's interest in S&T can cluster and be understood as collective identities which complement studies of gender and age as main discriminators of interest. Some earlier work in this direction has been done by Oskarsson and Karlsson (2011), showing that categories such as Human Health, Space, Spectacular phenomena, Environment, Technology, and Supernatural phenomena cluster students' interest in S&T within them. In a similar direction, Krapp & Prenzel (2011) suggested a way of theorising research on students' interest in S&T is by making use of the "person-object theory of interest". In this view, interest has an intrinsic character, it's 'self-intentionality' which means that a person critically evaluates different activities. Choosing to be engaged in an activity creates 'interest patterns' because when you grow up and search for identity, you cannot be interested in everything. You become selective, which is the mechanism behind the 'differentiation hypothesis", i.e. interest is expected to cluster along differentiated patterns. Krapp & Prenzel (2011) stated that such processes do not merely depend on the intrinsic dimension but also depending on previous experience. Hence, interest is seen as developmental and evolves out of relationships. The authors

make a point that such interest patterns have been poorly described in the research literature but can be done with large scale quantitative data. The work presented in this paper builds on this development and presents seven interest patterns empirically investigated in a large-scale research study.

METHODOLOGY

The empirical data used in the present study is Swedish and part of a large comparative international research study called the Relevance of Science Education Second (ROSES) which builds on the ROSE study (Sjøberg & Schreiner, 2019). ROSE grew out from collaboration among researchers and IOSTE has been a key platform and still is in the development of ROSES. Quantitative data is collected by an updated master questionnaire. Everything about background, rationale and questionnaire design is described in the ROSES handbook (Jidesjö, Oskarsson, & Westman, 2020). The Swedish data used in the work presented here were collected in spring 2000 with a national sample of 610 secondary students. The category used consists of 78 items concerned with "What I want to learn about". The items are composed of various S&T content, presented on a four graded Likert scale ranging from "not interested" to "very interested". To investigate interest patterns data were analysed with exploratory factor analysis with a varimax rotated solution, meaning that all factors are linear independent, with zero correlation between different factors (Oskarsson & Karlsson, 2011).

RESULTS

The explorative factor analysis reveals latent factors (interpreted as interest patterns) behind the students' answers. Seven different factors explained 50 percent of the variance and are presented below in Table 1. The results present items from questionnaire with high loading (correlation) for each factor. The content belonging to the different factors determine the name for each.

Seven factors presented with their respective Sums of Square Loadings (SSL) which explains to what extent each factor explains of the total variance in the answers. Three items from the questionnaire with high loading for each factor is given, together with a proposed name of the factor.

1. SSL 11.7%, "Environment & sustainability".

- How energy can be saved or used in a more effective way
- Renewable sources of energy from the sun and the wind
- The greenhouse effect and how it may be changed by humans

2. SSL 8.1%, "Spectacular phenomena, chemistry & space".

- How the atom bomb functions
- Biological and chemical weapons and what they do to the human body
- Rockets, satellites and space travel

3. SSL 7.2%, "Nature of science".

- Big blunders and mistakes in research and inventions
- Why scientists sometimes disagree
- Inventions and discoveries that have changed the world

4. SSL 6.8 %, "Health, drugs & the body".

- What we know about HIV/AIDS and how to control it
- How different narcotics might affect the body
- Sexually transmitted diseases and how to be protected against them

- 5. SSL 6.2%, "Hearing and vision".
 - How the eye can see light and colours
 - How the ear can hear different sounds
 - How different musical instruments produce different sounds
- 6. SSL 5.5%, "Earth and natural science".
 - Earthquakes and volcanoes
 - Tornados, hurricanes and cyclones
 - How meteors, comets or asteroids may cause disasters on earth

7. SSL 5.1%, "Supernatural phenomena and wonder".

- Thought transference, mind-reading, sixth sense, intuition, etc.
- Ghosts and witches, and whether they may exist
- Why we dream while we are sleeping, and what the dreams may mean

DISCUSSION

The results present seven concrete factors of students' interest in S&T interpreted by the "personobject theory of interest" where interest is expected to differentiate as 'interest patterns' (Krapp & Prenzel, 2011). Such interest patterns are supposed to evolve from a person's 'self-intentionality' as well as from external factors due to experience. Reactions to external experience can form collective behaviour creating collective identities (Hosek & Soliz, 2016). The interest patterns present a more detailed character of S&T interest among secondary students, pointed out by Osborne, Simon & Collins (2003) as important to take the research further. The naming of the factors is tentative and should be understood as work in progress. The researchers are careful when it comes to giving expression to the factors as 'collective identities'. Nevertheless, the seven (7) different factors identified in this research are *Environment & sustainability*, *Spectacular phenomena, chemistry & space, Nature of science, Health, drugs & the body, Hearing and vision, Earth and natural science,* together with *Supernatural phenomena and wonder,* explained the 50 percent of the variance in this quantitative data set.

The students who gave answers to the questions in the present study grew up during the first part of the 21st century where the development of S&T such as the Internet, smart-phones and social media creates new opportunities for experience and collective reactions to form different identities (Hosek & Soliz, 2016). The reasons behind the clustering presented here is an important research task to investigate further to understand something about causality. In fact, the authors are currently working on analysing possible correlations with other groupings to give further character of the patterns. The novelty of the present study is that the research design works and connects to the theoretical development by giving an empirical basis with S&T content to the constructs in use. Important future work should be done to corroborate the findings with other research designs and to compare differences in terms of cultural, religious or ethnical factors, which is progressing in the publication of ROSES studies around the world. In conclusion, theorising quantitative data on students' interest in S&T with the concept of 'interest patterns' and 'collective identities' works to develop the research field. The seven different empirically grounded patterns of interest presented here can be further investigated in which international collaborations and discussions are highly encouraged to make S&T more relevant to future generations in different parts of the world.
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ChatGPT AND ACTIVIST SCIENCE EDUCATION: POTENTIALS, CHALLENGES, AND CRITICAL APPROACHES

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ABSTRACT

Since its launch, ChatGPT has elicited much scholarly debate regarding its potential and risks/challenges, particularly in relation to educational implications. In one way, ChatGPT can be a useful means for students to engage in learning about socioscientific issues (SSIs) and social and environmental problems related to developments in STEM fields (STEM-SE issues/problems). However, among the several issues/problems associated with ChatGPT, intentional and unintentional biases and misinformation embedded in this language model's training data that can be reflected in its responses tend to be particularly concerning, specifically when considering needs for credible/trustworthy sources to inform civic decisions and actions on SSIs/STEM-SE issues. In this paper, which is based on literature review, we conceptualize ChatGPT both as a socioscientific/STEM-SE issue and as a means to learn about and address socioscientific/STEM-SE issues. We discuss related potential and risks/challenges, particularly in relation to misinformation. Further, we discuss possible approaches to inform critical usage of ChatGPT to learn about, and possibly address, different SSIs/STEM-SE issues and problems.

Keywords: ChatGPT, Generative Artificial Intelligence (GAI) Systems, Socioscientific Issues, STEM Issues, Activist Science Education

INTRODUCTION

Since its launch, in November 2022, ChatGPT has elicited much scholarly debate regarding its potential and risks/challenges (van Dis et al., 2023), particularly in relation to educational implications (Hsu & Ching, 2023; Mao et al., 2024). This new generative artificial intelligence (GAI) chatbot was trained on an enormous amount of publicly available text data (Murugesan & Cherukuri, 2023). Through its strong linguistic abilities, it can conversationally communicate in human-like language, and can assume different roles (e.g., teacher, student, scientist, poet, etc.) while performing a wide range of tasks, such as editing texts, drafting essays (including literature reviews), designing lessons and experiments, and answering questions to name a few (Ahmad et al., 2023; Johri et al., 2023). The capabilities of ChatGPT (and other similar GAI models), along with its *relative* accessibility (particularly its free version), appear to 'revolutionize' education (for the better or worse), inviting educators to rethink premises and goals of education (Popenici et al., 2023), while acknowledging what might be perceived as 'inevitable' roles of these technologies in our societies.

With these considerations, what possible roles might ChatGPT (and other similar technologies) play in relation to activist science education? Developments in STEM fields continuously give rise to controversial socioscientific issues (SSIs) (e.g., genetic testing), as well as to serious social and environmental problems (STEM-SE problems), such as climate change (Klein, 2014), digital surveillance (Lupton, 2016), and biased governance related to weapons development (Wilke, 2017). Addressing these issues and problems requires science education that can support citizens in making *science-informed* decisions that involve ethical and moral reasoning (Sadler & Zeidler,

2004). Further, it necessarily calls for science education/literacy that can foster citizens' active engagement in *informed* sociopolitical actions to change these realities (Bencze, 2017; Hodson, 2011; Reis, 2014; Sjöström et al., 2016). Recently, given the abundance of and ease with which misinformation spreads, there have been calls to reconceptualize notions of scientific literacy to include "digital media literacy" and educating students about "social practices of science" to support their judgments regarding possible credibility of science-related information (Osborne & Pimentel, 2023, p. 558). As ChatGPT is one main source of digital information (e.g., regarding SSIs/STME-SE issues), and as a controversial product of STEM developments, ChatGPT bears significant potential and risks/challenges for science education for active citizenship.

In this paper, which is based on reviews of relevant literature, we conceptualize ChatGPT both as a socioscientific/STEM-SE issue and as a means to learn about and address socioscientific/STEM-SE issues. We discuss its potentials and risks/challenges, particularly in relation to misinformation. Further, we discuss possible approaches to inform the critical usage of ChatGPT to learn about, and possibly address, different SSIs/STEM-SE issues and problems.

ChatGPT AS A SOCIOSCIENTIFIC/STEM-SE ISSUE

As a new educational technology, ChatGPT provides considerable potential and raises significant risks/challenges to activist science education. ChatGPT's strong linguistic competencies, and its abilities to mine vast online databases and to present customized content comprehensively (Murugesan & Cherukuri, 2023), can support learners' quick access to a wide range of well-arranged information on their topics of interest. Its multi-lingual conversational style seems promising in facilitating interactive and personalized learning experiences (Ahmad et al., 2023; Hsu & Ching, 2023), with possible language support for non-Native English speakers (Farrelly & Baker, 2023). These capabilities have suggested possibilities to accelerate task performance (van Dis et al., 2023) and might suggest potentials to increase access and equity.

However, it is not that simple. For one thing, there are socio-environmental issues related to developing and using ChatGPT. For example, the development stages of ChatGPT have been criticized for exploiting low-paid moderators in developing countries while exposing them to traumatizing content (e.g., violent content, sexual abuse, child abuse) (Rowe, 2023). There are also environmental issues associated with the significant power needed for processing data and cooling hosting cloud centres, and those associated with mining to support hardware development (Copper, 2023; Johri et al., 2023).

As for equity, there have been arguments and indications that ChatGPT (and similar GAI technologies) might widen existing inequalities (Giannini, 2023), for example, between developing and developed countries (van Dis et al., 2023), or in relation to individuals' digital skills and literacy and their abilities to access and use latest GAI technologies (Wach et al., 2023). Additionally, while accelerating task performance, ChatGPT's outcomes can be seriously problematic. For example, ChatGPT 'hallucinations' (i.e., reporting false/incorrect information) have been reported (OpenAI, 2023, p. 46), even sometimes for basic science concepts (Gregoris & Pendrill, 2023). The free version of ChatGPT (3.5) was trained on data available before 2021; therefore, it might provide outdated information (Hsu & Ching, 2023), and the most recent breakthroughs might be out of these technologies' reach (Watts et al., 2023). More importantly, there are significant issues with data sources on which ChatGPT (and other similar GAI technologies) was trained that can be reflected in its responses. Besides biases and stereotypes that are embedded in the training data (Mao et al., 2024; Popenici et al., 2023), and when concerning science/STEM related issues, information that is publicly available (and from which ChatGPT draws its responses) can sometimes be intentionally manipulated and distorted, by influential stakeholders to hide, alter and/or misrepresent problematic aspects of STEM products and/or related controversies (Aho, 2017). Hence, through their interactions with ChatGPT, students/learners may be engaged in a body of data that might already be partially questionable

and skewed. And with the absence of citations in ChatGPT's responses (van Dis et al., 2023), students/learners would probably have fewer chances identifying the credibility and trustworthiness of the sources of information, which is argued to be a significantly needed skill for citizens to face science-related misinformation (Osborne & Pimentel, 2023).

What might further complicate these interactions is that ChatGPT tends to 'imitate disciplinary discourse' (i.e., using disciplinary language and vocabulary without understanding its content) (Gregoric & Pendrill, 2023, p. 7). Additionally, in its responses, the chatbot tends to "position itself as the ultimate epistemic authority, where a single truth is assumed without proper grounding in evidence or being presented with sufficient qualifications" (Cooper, 2023, p. 444). The combination of the chatbot's strong linguistic abilities (including disciplinary language and logical arguments) and the 'confidence' it shows in its responses makes these responses appear as credible and might allow biases and misinformation to be unnoticed (Gregoric & Pendrill, 2023; van Dis et al., 2023), particularly for those inexpert in the issue/field.

Besides these issues, and when considering ChatGPT as a teaching/learning tool, some critics have pointed to the apparent limited (if any) roles of teachers/educators in the developments and vetting of GAI technologies, and how this can affect their educational implications (Abdelghani et al., 2023; Giannini, 2023). Abdelghani et al. (2023), for example, indicated a possible "lack of pedagogical stance" in the behaviour of these GAI models, as they are designed to mainly answer questions rather than to involve users/students in pedagogically sound and active learning experiences (p. 1). Indeed, in an experimental interaction between the first author and ChatGPT 3.5 regarding SSIs, and upon a request to "give an example of how a secondary school teacher might involve students in ethical considerations about an SSI", the chatbot chose the use of CRISPR-Cas9 technology as an example of issues around genetic engineering and proceeded to give a detailed related lesson plan (Figure 1). While the lesson plan touched upon different aspects of the issues and included interactive activities, exploring students' preconceptions about this issue (a necessary step to involve students in meaningful learning experiences) was surprisingly missing. And when asked about this missing step, the chatbot confirmed its significance, stated its benefits, and then revised the lesson plan to include a related activity (Figure 2). With these considerations, and with these technologies being already in use, there have been calls for educators and researchers to critically examine their educational suitability and to develop research-informed and pedagogically sound approaches and applications to support their educational usage (Abdelghani et al., 2023; Giannini, 2023).

To sum up, and while acknowledging ChatGPT's popularity and embracing its educational potential, there are significant concerns regarding the credibility of its responses and educational experiences in which it might involve its users. There are also needs for educators and researchers to develop relevant critical approaches to engage students/learners in meaningful learning experiences. When considering SSIs/STEM-SE issues, for example, students might use ChatGPT to explore these issues, analyse them, and perhaps request *suggestions* for actions (e.g., how to make a product more sustainable, or how to make their actions more effective). However, it is probably justified to question the responses: What information might have been hidden or distorted? Which stakeholders, perspectives, and/or interests have been represented/silenced? Are the suggestions provided based on sound knowledge?

In the next section, we discuss the main themes regarding recommendations and possible approaches to improve educational usage of ChatGPT, particularly in relation to SSIs/STEM-SE issues.

USING ChatGPT TO ADDRESS SOCIOSCIENTIFIC/STEM-SE ISSUES

When considering how to critically improve educational usage of ChatGPT and other similar GAI technologies, one significant recommendation has been to improve users' (both students and teachers) GAI literacy (Abdelghani et al., 2023; Farrelly & Baker, 2023; Mao et al., 2024).

Included in this overarching theme are needs to educate users about issues related to ChatGPT usage (similar to those discussed above), and to support them to develop knowledge and skills to craft meaningful prompts (Hsu & Ching, 2023; Johri et al., 2023; Vasconcelos & dos Santos, 2023) and to critically evaluate the chatbot's responses (Ahmad et al., 2023; Cooper, 2023; Halaweh, 2023).

ChatGPT Certainly! Let's take the example of genetic engineering and the use of CRISPR-Cas9 technology. This is a socioscientific issue that involves both scientific advancements and ethical considerations. **Lesson Plan: Exploring Ethical Considerations of Genetic Engineering** **Objective:** To engage students in critical thinking about the ethical implications of genetic engineering using CRISPR-Cas9 technology. **1. Introduction (10 minutes):** Briefly introduce the concept of genetic engineering and CRISPR-Cas9 technology. Discuss potential benefits, such as the treatment of genetic diseases, and the ability to modify crops for increased yield. - Mention potential concerns, including ethical considerations related to human gene editing and environmental impacts. **2. Case Study Analysis (20 minutes):** Provide students with a case study that highlights a real-world example of CRISPR-Cas9 use, such as the editing of human embryos to prevent genetic diseases. - In small groups, have students analyze the case study and identify the scientific aspects as well as the ethical considerations involved. - Encourage discussion on questions like: What are the potential benefits of using CRISPR-Cas9 in this context?
What ethical concerns arise from manipulating the genes of embryos?
How might this impact individuals, families, and society? **3. Ethical Frameworks (15 minutes):** Introduce ethical frameworks, such as consequentialism, deontology, and virtue ethics. - Discuss how these frameworks can be applied to evaluate the ethical implications of genetic engineering. Ask students to consider the case study from different ethical perspectives and discuss the potential outcomes based on each framework. **4. Classroom Debate (20 minutes):** - Divide the class into two groups: one representing proponents of CRISPR-Cas9 use in the given context and the other representing opponents. - Conduct a structured debate where students present their arguments, considering both scientific and ethical aspects. Encourage students to use evidence and ethical principles to support their positions. **5. Reflection and Discussion (15 minutes):** Conclude the lesson with a reflection session where students share their thoughts on the ethical considerations of genetic engineering. Discuss how their perspectives may have evolved throughout the lesson.
Emphasize the importance of considering both scientific advancements and ethical implications in decision-making. This lesson plan engages students in exploring a real-world socioscientific issue, encourages critical thinking about ethical considerations, and promotes informed decision-making. It also provides an opportunity for students to articulate and defend their viewpoints, fostering a deeper understanding of the complexities involved in such issues.

Figure 1: ChatGPT's initial response (i.e., lesson plan) regarding involving secondary school students in ethical considerations about a socioscientific issues (CRISPR-Cas9 technology)



Figure 2: Part of ChatGPT's revised lesson plan to include activity to explore students' preconceptions about CRISPR-Cas9 technology

As for GAI literacy, there have been advocacies for forms of literacy that go beyond technical ones (e.g., learning how to use these technologies) to include understanding how these models work, possible potentials, limitations, and biases, and related socio-ethical implications and applications (Abdelghani et al., 2023; Farrelly & Baker, 2023; Mao et al., 2023). It could be argued then, that teaching/learning about possible embedded misinformation (e.g., related to SSIs/STEM-SE issues), and possible causes/sources and consequences, should be an integral part of educational approaches to develop critical GAI literacy.

One possible approach to *partially* improve ChatGPT's responses is to focus on crafting good prompts that might elicit more meaningful responses. For example, using specific and goaloriented prompts is argued to improve GAIs' behaviour (Abdelghani et al., 2023). Asking GAI tools to assume or describe different roles (e.g., "teacher, doctor, scientist, or construction worker") is suggested to identify biases in GAIs' responses (Farrelly & Baker, 2023, p. 11), and might be particularly relevant when approaching SSIs/STEM-SE issues where stakeholders and involved entities might have different perspectives, interests, and/or power positions in the issue.

While crafting good prompts seems significant to improve learning experiences with ChatGPT, it is not sufficient, particularly when considering misinformation. As such, it is crucial that ChatGPT's responses are critically evaluated (e.g., against credible data/resources). Halaweh (2023), for example, suggests that students conduct "reverse searching" to find more about the topic and to well cite the provided claims (p. 5). Taking further, Popenici et al. (2023) asks students to identify 'what is missing' (e.g., in a ChatGPT generated literature review) in order to engage them in thorough learning experiences. However, to further inform these (and other similar) techniques, as well as to craft good prompts, Bencze et al. (Forthcoming) recommend teaching students relevant concepts/themes on which they can base their evaluation/search/prompts. For example, when considering SSIs/STEM-SE issues, concepts from fields of Science and Technology Studies (e.g., Actor-Network Theory - Latour, 2005) have been suggested to inform students about ideas/lenses (e.g., inclusion, positions, interests, and/or perspectives of different (a)biotic actants) that they might not have considered before (ibid).

There are but a few approaches to support critical usage of GAI technologies; however, much effort is still needed to embrace the potentials of these technologies while addressing current and other possibly evolving related issues.

CONCLUSIONS

To conclude, GAI systems (including ChatGPT) are in the 'infancy' of developments. They have potential to involve students in valuable learning experiences regarding SSIs/STEM-SE issues and to inform/support their actions. However, it is significant to base these experiences on sound pedagogies and critical lenses and approaches to well inform students' learning and actions. Nevertheless, the rapid developments of these systems by private sectors, accompanied by limited government regulations (Giannini, 2023), might cast significant challenges to these educational efforts. At the end, it is justified to ask, how can be truly protected against failings aspects of GAI systems without meaningful government regulations?'

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PRE- AND IN-SERVICE SCIENCE TEACHERS' STAGES OF CONCERN REGARDING THE REQUIREMENT TO FOSTER STUDENTS' COMPETENCE DEALING REFLECTIVELY WITH SOCIO-SCIENTIFIC ISSUES

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ABSTRACT

According to reforms in the national education standards of Germany (KMK, 2005), science teachers are required to foster competence not only concerning scientific principles and concepts, but also in the field of dealing with socio-scientific issues. The fulfilment of this requirement presents new challenges to teachers, and it still seems to be a source of serious difficulties in school practice. Hence, we asked: *How do prospective and active science teachers regard the professional challenges and opportunities concerning the fostering of the SSI assessment of students?* To pursue this question, the "Stages of Concern model" (SoC) was used to analyse the (un-)willingness of science teachers (and science teacher students) to implement an educational innovation like the one just mentioned. The existing SoC-Questionnaires were applied to our subject, optimized them, and asked science teachers to fill in the questionnaire. This treatment-control designed study consisted of 110 (pre- and in-service) science teachers. The analyses identify the SoC-Profile of the "cooperator" regarding the two control-group sub-samples and the SoC-Profile of "teachers in action" regarding a specific treatment-group.

Keywords: Socio-Scientific Issues, (Pre- and In-service) Science Teachers Education, Science Teachers' Professional Concern, Stages of Concern Model

INTRODUCTION

The successful implementation of curricular innovations and reforms is mainly affected by the acceptance of those affected by such changes (Fullan 2000; Coburn 2003). The introduction of national educational standards in Germany as demanded by the Standing Conference of the Ministers of Education and Cultural Affairs [in German: Kultusminster Konferenz; in short: KMK] (2005 a-c) presented teachers with new challenges, requiring them to foster not only subject specific competences, but also student competence in the areas of methods for the acquisition of scientific knowledge, communication skills, and the competence to deal with socioscientific issues (SSI) in a reflected and responsible manner. In light of this fact, it is suspected that even almost twenty years later the implementation processes of the KMK agreements (2005) are still far from complete. Therefore, a great need for action is still seen, particularly in the area of how to convince science teachers and science teacher students to foster their students' ability to assess and evaluate socio-scientific issues and to critically reflect on the effects of the sciences on society with respect to goals for sustainability. For this reason, the issue in this investigation is: How do (pre- and in-service) science teachers assess the professional challenges and opportunities that they face concerning the implementation of the KMK Standards (2005) in general and the requirement of fostering students' competences regarding SSI assessment and decision-making in particular?

Theoretical Framework

To pursue this general question, the Stages of Concern (SoC) model elaborated by Fuller (1969) and its adaptation by Hall and Hord (2011) were used. The SoC model is a proven model for analysing the (un)willingness of individuals to implement educational innovations. According to

Fuller (1969) and Hall and Hord (2011), the successful adoption of an innovation takes place over four SoC dimensions which are differentiated into seven different stages (so-called "stages of concern" [SoC] (Figure. 1).



Figure 1. Stages of Concern Model according to Fuller (1969) and Hall and Hord (2011)

The SoC Model has already been successfully used in various implementation studies (George et al. 2008; Pant et al. 2008; Oerke, 2012; Kwok, 2014; Pöhlmann et al. 2014; Böse et al. 2018; Teerling et al. 2018; Bolte & Schneider, 2014). While Pant et al (2008) have already applied the model to the implementation of national educational standards in general, the competence area of dealing with SSI has not yet been explicitly considered. This is surprising, because the promotion of this competence is generally regarded as a particularly demanding task (AAAS, 1993; NRC, 1996; Bybee, 1997; Bolte, 2008; Bolte & Schulte, 2014; Menthe et al. 2016; Bolte & Gauckler, 2018), which confronts many teachers with challenges that they often face with uncertainty (Alfs et al. 2012; Mrochen & Höttecke, 2012).

The adapted SoC Questionnaire by Hall and Hord (2011) using the German translation by Pant et al. (2008) as well as the adaptation of Bolte and Schneider (2014) for science educational research and to apply the corresponding scales to the issue of fostering the students' assessment competence in science lessons was used. Beside these objectives of adapting existing SoC questionnaires, attempts were made to semantically optimize the combinations of the scales and the corresponding items and to shorten the original questionnaire in terms of the number of items, because feedback were received from various teachers who participated in previous studies (Bolte, & Streller, 2012; Bolte & Schneider 2014; Bolte, Schneider & Schürmann, 2014) expressed their discomfort to complete items they thought they had already completed before.

Research Questions

Based on these theory-based considerations, we arrived at the following research questions:

To what extent does our adapted SoC questionnaire fulfil the criteria of scientific quality? If our adapted SoC questionnaire provides satisfying psychometric features compared to other studies (see above), we also investigate whether we can find the typical "SoC Profiles" according to the studies of Bitan-Friedlander et al. (2004). In this context we ask:

To what extent do the (pre- and in-service) science teachers' SoC Profiles show one (or more) of the typical SoC Profile(s) and to what extent do the SoC Profiles of in-service science teachers and chemistry teacher students differ; especially when the chemistry teacher students participate in a specific chemistry teacher training course dealing with the issue of how to promote students' competences to make scientifically informed and reflected decisions in the context of socio-scientific issues in chemistry lessons?

METHODOLOGY AND DESIGN OF THE STUDY

In order to examine the research questions, at least two (plus one) (sub-)samples involved were: a pre- and an in-service science or chemistry teachers' sub-sample representing the two controlgroups of the study as well as in addition a pre-service chemistry teachers' (sub-)sample who participated in the CPD- course; these students represent the treatment-group in our investigation.

To identify differences between these (three) groups, an adapted version of the German questionnaire of the SoC according to Pant et al. (2008) with reduced number of items from 42 to 28 items (four items per scale). Each item is combined with a 7-point Likert scale from "Not true of me now" (coded: "1") to "Very true of me now" (coded: "7"). Furthermore, if an item is irrelevant for the participant at that moment there is the possibility to choose the option "irrelevant for me at the moment" (coded: "0").

To identify SoC Profiles according to Bitan-Friedlander et al. (2004) and to describe the Concerns-Profiles toward the innovation in more detail, the reliability for each scale and calculate factor analysis (Eid & Schmidt 2014) was first checked. Furthermore, the Mann-Whitney-U-Test was calculated to test and identify possible statistically significant differences between the (three) subsamples.

RESULTS AND DISCUSSIONS

The sample in total includes 110 participants: 31 in-service (control group 1) and 31 pre-service science teachers (control group 2) as well as 42 chemistry teacher students (mainly in the bachelor program and with first experience in teaching chemistry classes) who participated in the CPD course mentioned above (treatment group).

The analyses of reliability provided by Cronbach's alpha coefficients are for all SoC-scales higher than .70 and indicate an acceptable level of reliability for the seven Stages of Concern (.75 < α < .93).



Figure 2. SoC profiles of the treatment group sample (science teacher students) and two control group sub-samples (a) in-service science teachers and (b) pre-service science teacher students

The factor analyses show that the items are loading high on the factors to which they theoretically should belong regarding the SoC Model.

However, the results of the Mann-Whitney-U-test show no statistically significant differences within the two control groups but statistically significant differences between the two groups of participants who did and did not participate in the CPD treatment course (Figure. 2).

Comparing the identified SoC Profiles, it is concluded that the SoC Profiles from both control groups are quite similar to the ones identified by Bitan-Friedlander et al. (2004) in terms of the SoC Profile of the "cooperator" (Figure 2). Comparing the SoC Profile of the treatment-group with other SoC Profiles, it is identified as a SoC Profile which is very similar to the SoC Profile labelled as "teacher of action". The study shows that the adapted questionnaire version is theoretically sound, and the scales are reliable. In the analyses, the SoC Profile of the "Cooperator" (Bitan-Friedlander et al. 2004) was identified. This demonstrates that both control groups (the pre- and in-service science teachers who did not visit the CPD course) show (only) moderate interest in the implementation of the requirement to foster students' ability to deal with SSI in a reflected and responsible manner. Therefore, the conclusion made is that there is still a need to make science teachers and science teacher students familiar with the issue and educational goal to enhance students' competence in dealing reflectively with socio-scientific issues and to convince in- and pre-service science teachers. This conclusion becomes obvious when the focus is on the SoC Stage "Awareness"; neither group is very much aware of the requirement nor currently involved in designing lesson plans serving this requirement (Bolte & Gauckler, 2018). Looking at the feedback provided by the science teacher students' treatment group, it can be concluded that a change regarding the teachers' professional concern is possible and becomes likely if science teacher education programs offer attractive, meaningful and supportive CPD courses. These CPD courses for science teachers should be based on serious and reliable findings from the field of science education research and the impact of these CPD courses could and should be evaluated systematically - for example on a first step by means of the Stage of Concern Model and the questionnaire based on the empirically proven model.

CONCLUSIONS

Hall and Hord (2011) mentioned that the development of professional attitudes and concerns can take years and depend on the attractiveness of the educational program. In contrast to their time scale, the results of this study show that it is possible to affect the participants' professional attitudes and concerns – in this case regarding the implementation of SSI-oriented teaching approaches in a positive manner within a training course of 10 meetings. However, and with respect to the theory of planned behaviour (Ajzen, 1991), there is a high probability that the participants will implement SSI-related teaching in future lessons because attitudes do not necessarily coincide with the corresponding behaviour. Therefore, an analysis on how far the (preservice) teachers really implement SSI in their future science lesson plans have to be carried out.

All in all, the results show that it is possible to affect (pre- and in-service) science teachers' professional concerns regarding the implementation of SSI-oriented teaching approaches in a positive manner by means of the CPD program developed. However, it can be concluded that the results emerged for a small number of participants and within the framework of a first treatment-control intervention. Hence, it is acknowledged that the CPD course that has been developed still has to prove itself in further pre- and in- service teacher education programs.

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LEARNING WITH AND ABOUT GENERATIVE ARTIFICIAL INTELLIGENCE AND OTHER TOOLS IN A GRADUATE COURSE CONCERNING SOCIETAL IMPLICATIONS OF DIGITAL TECHNOLOGY

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ABSTRACT

This presentation discusses the integration of digital tools, including generative artificial intelligence (AI) and the social annotation tool Perusall, in a graduate course focused on the societal implications of digital technology. The course was conducted in an online setting and aimed to enhance educators' understanding of societal impacts of digital technology in order to facilitate their teaching about it. Generative AI was used for synthesizing materials, generating teaching ideas, and critically evaluating AI's capabilities and limitations. Perusall facilitated collaborative annotation of digital resources, promoting student engagement. The findings offer insights into the effective use of these tools in higher education, particularly in fostering critical discussions about digital technology's societal effects.

Keywords: artificial intelligence, social impacts, graduate education

INTRODUCTION

Digital technologies including generative artificial intelligence and social media are having a profound impact on society at large, including youth. It is important that educators have a clear understanding of these impacts and how to communicate them to their students. Professional development for educators is increasingly occurring in online settings, resulting in the need for strategies to teach about this content using this modality.

This presentation discusses the application of two kinds of digital tools in an online university course for educators to support learning about the societal implications of digital technologies. One tool was generative artificial intelligence, and the other was Perusall, a platform for collaboratively annotating digital resources (Cecchinato & Foschi, 2020). The university course is part of a master's program in educational technology in the USA. The presentation discusses the use of these tools to support university students' discussion of and reflection regarding these topics.

The use of generative AI in university courses as a support for educators is an emerging area (Baidoo-Anu & Ansah, 2023). As such, it is worthwhile to investigate ways that educators can use generative AI as a support for their own learning as well as a support for their teaching practices. Generative AI offers significant potential to enhance learning and equity in higher education. It can provide personalized instruction, automated assessment, and support for diverse student populations, including those with special needs. AI tools can assist in content creation, recommending resources, and research, while also improving inclusivity. While offering promising benefits, AI also brings with it a host of risks and negative impacts. For all these reasons, generative AI was useful in this setting not only as something to learn with but also as something to learn about.

Perusall was used to allow students to collaboratively highlight and comment on passages in articles in an electronic format, or similarly, to collaboratively comment on videos (such as documentaries, news stories, and YouTube materials) or audio materials (such as podcasts) in

particular locations. This is intended to make the activity of reviewing and considering the implications of specific passages to be a more social process.

METHODOLOGY

The course spanned 15 weeks and had 19 students who were K-12 teachers or worked in higher education in educational technology. The subject matter of the course concerned topics including the societal implications of social media and YouTube (Haugen, 2022; Faddoul, Chaslot, & Farid, 2020), cultural impact of digital technology (Turkle, 2016), gender and technology (Acilar, & Sæbø, 2023), racial bias in algorithms and AI (Buolamwini, 2023), and societal impacts of surveillance capitalism (Zuboff, 2023). Given the course content, the use of digital tools, particularly generative AI, was all the more pertinent to afford educators direct experience using these tools to investigate course content. Educators used the Perusall tool with 25 digital resources. They used generative artificial intelligence throughout weekly modules in the course.

RESULTS AND DISCUSSION

Data from these activities are being analysed qualitatively to identify themes in students' use of these tools. The presentation demonstrates examples of the applications of these tools, discusses how students made sense of the material using them, and reports on students' feedback regarding the use of these tools in this area.

Educators used the social annotation tool to critique and elaborate on specific arguments made in the digital materials as well as to respond to one another's critiques. Educators used generative artificial intelligence to synthesize and compare materials in the course, explore further areas, generate ideas for teaching about the material in K-12 settings, and create draft instructional materials. They also explored capabilities, limitations, and biases of generative AI tools by using them and critically evaluating their outputs.

Information gained from this analysis is being used to revise instructional approaches for a subsequent cycle. The outcomes may also be of broader interest, illustrating uses and issues associated with using these tools in the service of teaching about the societal implications of digital technology.

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EMPOWERING EARLY CHILDHOOD TEACHERS TO TEACH SCIENCE THROUGH A CONTINUOUS PROFESSIONAL LEARNING PROGRAMME IN MAURITIUS

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ABSTRACT

The teaching and learning of science is considered as the weakest point in the education system at early childhood level in Mauritius as early childhood teachers do not have the necessary pedagogical content knowledge to effectively teach science. Support provided to teachers via one-off workshops seems to be unsuccessful as they tended to be viewed as an event rather than a process in the teachers' transformative practice. This study reports on the findings that a continuous longer term professional learning programme had on early childhood teachers' experiences towards the teaching and learning of science. Such continuous professional learning (CPL) programmes provide teachers with frequent opportunities to engage in hands-on activities during CPL workshops, implement the different pedagogies in their classrooms between workshops, collaborate with peers and share classroom practices and knowledge. Mixed method research was adopted, and data were gathered via pre and post workshop survey questionnaires and focus group interviews. This paper presents the findings regarding the impact the program had on the experiences of participating early years teachers. The paper also discusses how these educators implemented the workshop pedagogies into their classroom practices and aims to identify the challenges early childhood teachers face in teaching and learning science.

Keywords: early childhood education, inquiry-based science learning, continuous professional learning programme

INTRODUCTION

Young children are naturally scientists as they are curious of world around them, which they like to explore through their senses (Trundle, 2010). Thus, it is imperative to provide them with guidance and opportunities that can tap on their natural curiosity to help them to acquire basic develop scientific knowledge and inquiry skills (French, 2004). The teaching and learning of science is best done using child-centred approaches which foster active engagement of the learners (Pakombwele, 2022). Such approaches include guided discovery, experiments and exploration, promote the development of scientific inquiry skills such as observation, investigation and questioning. However, research conducted by Thulin and Redfors (2017), and Eckhoff (2017) have shown that early childhood teachers often find it difficult to design and implement appropriate activities for the teaching and learning of science in preschools either because they lack basic scientific knowledge or because they do not have adequate pedagogical content knowledge.

According to a study carried by Piasta *et al.* (2015), one way to support early childhood science teachers in their teaching of science is through professional development programme. Recently, attempts to enhance the teaching and learning of science, in preschools in the Republic of Mauritius have been made by several local institutions. These institutions have organised capacity building sessions and continuous professional development programme in the form of one or two-day workshop with early childhood teachers (Naugah *et al.* 2022; Kamudu Applasawmy *et al.* 2016).

However, research have shown that the 'traditional' form of professional development programme like the 'one-off' workshop does not have permanent impact on classroom practice (Hoban, 2002). Since there is little or almost no follow up after these 'one-off' workshops, the latter are often considered as an event rather than a process in the teachers' transformative practice. Thus, the 'traditional' form of professional development programme seems to be insufficient to address the change of mainstreaming the inquiry-based science activities at early childhood level in Mauritius. This study explores the design and use of a professional learning model which consists of a series of oneday workshops as an action based methodological approach to build capacity for early childhood teacher for implementing inquiry-based science learning. Such professional learning model seems to be a more fruitful transformative change for the participating teachers who will be actively engaged in a process of putting knowledge into practice. It also provides teachers with frequent opportunities to collaborate with peers, share classroom practices and knowledge and to reflect on their teaching experiences (Abakah, 2023; Darling-Hammond *et al.*, 2017; Desimone, 2009; Tannehill *et al.*, 2021).

The aim of this study is to investigate how a continuous professional learning (CPL) model can be used to empower teachers in Mauritius for the teaching and learning of science and inquiry-based learning activities at the early childhood level.

There are two (2) research questions in this study:

- i. What are the current opportunities and challenges that early childhood teachers face in the teaching and learning of science inquiry and why?
- ii. How far an action-based research methodological approach will help early childhood teachers to improve their teaching and learning of science by inquiry?

The objectives are:

- i. To identify the challenges early childhood teachers, face in the teaching and learning of science inquiry
- ii. To identify the most effective part(s) of the continuous profession learning model and understand why

METHODOLOGY

This research applied a concurrent mixed-methods design to study how a continuous professional learning (CPL) model can be used to empower teachers for the teaching and learning of science and inquiry-based learning activities at the early childhood level.

A total of 22 in-service early childhood teachers volunteered to participate in this study.

Four workshops were carried out during a span of 3 months. The first workshop focused on the use of fair test in science experiments using paper spinners. The rest of the workshops emphasised on the development of process skills using the POE (Predict Observe Explain) approach. Science experiments such as melting of ice and chocolate, floating and sinking, and dissolving of materials were carried out during these workshop sessions.

Pre and post-programme online survey questionnaires and semi-structured focus group interview were used to gather data in this study.

The online survey was administered to the participating teachers prior to the first professional learning programme workshop. The same survey was conducted with the teachers after the final workshop. The survey was built using Google form and it contained 11 Likert type of statements to explore the participating teachers' views about the teaching of science at early childhood level using five response options (strongly disagree, disagree, neither agree nor disagree, agree and strongly agree). The statements were related to methods on the teaching of science and the importance of the scientific process skills.

Some of the survey statements are:

- I think it is important to provide my pupils with opportunities to carry out fair test investigations.
- I think it is important to provide my pupils with opportunities to safely try out their own ideas in investigations.

- I think it is important to provide my pupils with opportunities to work in groups in science lessons.
- I think it is important to provide my pupils with opportunities to talk about science.
- I think it is important to provide my pupils with opportunities to learn science through storytelling and picture books.
- I think it is important to provide my pupils with opportunities to learn science through play.
- I think it is important to provide my pupils with opportunities to apply and develop their observation skills.
- I think it is important to provide my pupils with opportunities to make predictions.

Descriptive statistics were used as the principal tool of analysis of the surveys. The responses of pre and post survey of the participating teachers were compared to study change.

A semi-structured focus group interview with the participating teachers was conducted at the end of the program to explore their professional perspectives on the structure and content of the professional learning program. The questions for the focus group interview are listed below. Questions 1 to 7 pertain to the content of the program, while questions 8 to 13 focus on its structure and delivery.

- 1. To what extent have you introduced new science teaching strategies (methodologies) into your science lessons as a result of involvement in the Professional learning workshop/s?
- 2. To what extent has your view of teaching science changed as a result of your involvement in the Professional learning workshop/s?
- 3. Do you think it is important to teach children about science? Why / why not?
- 4. Do you think engaging with science activities has had an impact on your pupils' science knowledge and skills? Please elaborate.
- 5. Have you observed any changes in your pupils' attitudes to science since your engagement in the Professional learning workshop/s?
- 6. Do you feel as confident teaching science now as you did before the workshop/s? Please elaborate.
- 7. Are there any factors that might prevent you from implementing the new teaching ideas / methodologies that you learnt about during the workshop into your science lessons in the future?
- 8. What did you want to achieve from your involvement in the workshop?
- 9. What did you gain most from your involvement in the workshop?
- 10. What do you think are the characteristics of effective professional learning?
- 11. Tell me about the way(s) in which you collaborated or worked with other teachers during the last few months in teaching science? What worked/ didn't?
- 12. Do you think collaboration with other teachers for the last few months in teaching science has had an impact on your own practice? Why/ why not?
- 13. Do you think the type of professional learning that was used throughout the science workshop(s) differed in any way to other in-service or professional development courses you have attended? Please elaborate.

The qualitative data collected were analysed using content analysis. Information about the teachers' experiences obtained from these data was used in the triangulation of the quantitative data from the surveys.

One of the major limitations of this study is the use of self-reported data from the focus group interview. The possible sources of bias for this self-reported data include selective memory, attribution, and exaggeration. However, several steps were taken to minimise potential biases and errors (Berkel *et al.*, 2020). For example,

- the data were collected two weeks after the last workshop.
- all the participants were invited to the focus group interview.
- responses were obtained from all participants.
- clear and unbiased questions were used for the interview.

RESULTS AND DISCUSSIONS

Quantitative data analysis

The 11 statements in the survey were examined using the paired samples Wilcoxon test. The test showed a median value of 5.00 (from 3.5 and 4.5 to 5.0) for all the statements (p < 0.05), thus indicating a statistically significant increase in the teachers' views about teaching of science after the workshops. The result for 6 statements given in methodology section is shown in Figure 1.



Figure 1. The 11 statements in the survey questionnaire grouped into three major themes namely: methods of teaching science, scientific process skills, and scientific attitudes and values

Figure 2 illustrates the teachers' views on the teaching of science according to these three themes, both before and after the learning program.



Figure 2. Teachers' views on the teaching of science according to three themes, both before and after the learning program

As shown in Figure 2, a larger proportion of the teachers strongly agreed with these statements, and no teacher strongly disagreed or disagreed after the program

Qualitative data analysis

Teaching of Science

During the focus group interview, some teachers stated that they implemented the new science teaching strategies (methodologies) into their science lessons whenever possible. One teacher mentioned that she provides her students with daily opportunities to develop science process skills, such as observation and prediction, by asking them to forecast the weather each morning.

The teachers pointed out that they are more motivated to conduct science activities after the workshop since they gained many new ideas. They recognise science process skills in all areas of learning. They observed that their students are more active, happier, and more curious when engaged in science activities. The teachers also mentioned that they now focus on the development of process skills rather than the outcomes of science experiments.

A few teachers stated that their students have applied the same set of process skills in other areas of learning of the Mauritius Early childhood National Curriculum Framework. These areas of learning include Mathematics and Logical thinking, Expressive Creative and Aesthetic Development and Personal, and Social and Emotional Development. According to these teachers, the students' interest in science has carried over to other subjects. The students pay closer attention to fine details, especially when drawing, such as including all their observations (e.g., an egg with its centre colored yellow). A few teachers also mentioned that they now search the internet to plan or find activities and prepare questions in advance for these activities.

These findings align with the increase in the percentage of views on the use of the different methodologies of teaching science after the CPL programme.

Professional learning programme

During the focus group interview, the teachers stated that they were quite impressed with the content of the workshops because of three main reasons. Firstly, they enjoyed the 4 sessions of the workshops because of its hand-on nature. Secondly, they never thought they can teach science activities using locally available materials, and thirdly because everything they have learnt is directly related to their teaching curriculum and have been implemented at school. Two main aspects that they really liked about the series of workshops were its duration and its sharing nature. They reported that the sessions were spanned over 3 months, so they had time to implement the activities they have learnt and to discuss with their peers each time they meet in the workshops. However, some of the teachers mentioned that they had difficulties to implement the activities because of the lack of resources at schools (schools do not provide them with the necessary resources) and too little curriculum time for science at school. Many schools focus more on numeracy and literacy.

CONCLUSIONS

The result of this study shows that the continuous professional learning programme (CPL) had a positive impact on the participating teachers. Their views about teaching science have changed and now they strongly believe that they must provide their students with opportunities to do experiments and develop their process skills. The CPL has motivated the participating teachers to engage in science activities and have had a positive impact on their students. However, the lack of resources for teaching science activities in preschool could undermine the positive effects of the CPL on the participating teachers.

The advantages of continuous professional development programme pointed out by the teachers aligned with the core features of an effective professional development programme put forward by Desimone (2009). According to the latter, these core features are active learning, focus on content/process, duration and collective participation. Thus, such type of continuous professional learning programme can be used to empower teachers to promote the teaching of science. The teachers are facing challenges to implement science activities due to little curriculum time. They might explore the possibility of integrating science activities with other subject areas within the curriculum, as one key aspect of the early childhood curriculum is the use of the integrated approach.

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CROSS-SECTIONAL STUDY OF THE TEACHING OF ASTRONOMICAL ELEMENTS IN PRIMARY EDUCATION

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ABSTRACT

Astronomy teaching has been gaining ground in Brazil in recent years. This increase is due to new curricular proposals, changes in initial and continuing teacher training, and the incorporation of research results in the production in teaching materials. In this context, this paper aims to present a cross-sectional study on the teaching of astronomical elements developed with students in the last segment of Brazilian primary education. The sources of information are the products created by the students during classes, semi-structured interviews conducted with the teacher, and the notes in the researcher's diary. Among the results, the study showed: (i) There is a direct link between the students' media experiences and the notions they obtained about astronomical elements; (ii) There is a tendency for students to always represent the Solar System associated with the Sun-Earth dyad, disregarding the other elements; (iii) The models constructed by the students primarily reflected what was presented by the teacher with no possibility of expansion.

Keywords: Astronomy education. Pedagogy. Primary education. Science education. Teaching methodology.

INTRODUCTION

This paper aims to present a cross-sectional study on the teaching of astronomical elements to 9thgrade students in Brazilian basic education. To this end, the sources of information used were the products prepared by the students, parts of a semi-structured interview conducted with the class's Science teacher, and the notes from the researcher's research's diary.

Furthermore, to analyse the data produced by the study, the hermeneutic-phenomenological approach according to Mometti (2023) was chosen. This approach is characterized by a reflective methodology that facilitates obtaining interpretations from data extracted from different sources through alethic process. Finally, it is worth highlighting that this text is part of research on the learning of Astronomy learning in primary education, which began in 2021 under the title "Astronomy for children", developed at School of Education, University of São Paulo, Brazil.

According to studies by Pacheco and Zanella (2019), the teaching of Astronomy in Brazil has been gained a respected place in terms of pedagogical practices, especially in the first years of basic education. Thus, as the same authors emphasize, one of the main difficulties in teaching Astronomy in Brazilian schools is the lack of teacher training. When we analyse the profile of the professional teaching in their first years of basic education, for example, we find that he or she is a "generalist" teacher, that is, a teacher trained in pedagogy with in-depth knowledge of scientific areas and responsible for developing for teaching scientific content in schools.

In this sense, teacher training in contemporary times needs to consider the type of relationship that students have with each other, those that develop between them and the teacher, as well as within the family nucleus itself. This means that the contemporary student, belonging to a digital and technological era, in which all human relationships are permeated by "likes" and "posts", brings to school specific needs and beliefs shaped by their consumption of digital media.

Thus, learning certain Science content requires the teacher to make methodological choices that take into account four specific aspects, according to Astolfi and Develay (2012), which are: (i) Choices of content that respect essential didactic aspects; (ii) Choices of pedagogical approaches that are aligned with the students' psychological moment; (iii) Selection of resources that are adapted to both the didactic and learning needs of the students.

Considering that contemporary students are digital native (Prensky, 2001), we can say that the practice of teaching contemporary Science should aim to disseminate findings and their interpretations through digital resources. This includes the teaching of Astronomy, which necessarily assumes the use of imagery elements constructed from telescopes and digital interpretations made with computational models.

Likewise, the knowledge conveyed by different media outlets will be consumed and interpreted, generating in students their forms of interpretation, both of simpler astronomical elements such as the Solar System, and more complex ones, such as stellar explosions, nebulae, supernovae, and black holes.

METHODOLOGY DESIGN

To achieve the objectives proposed for this study, the first methodological choice was the collection of information sources provided by the products generated by students during Astronomy classes at school, excerpts from a semi-structured interview conducted with the class teacher, and observations recorded in the researcher's field diary.

As a second methodological choice, the hermeneutics-phenomenology as outlined by Mometti (2023) was selected. Figure 1 below illustrates the application of such methodology, which is referred to as reflexive in the literature (Alvesson & Sköldeberg, 2009).



Figure 1: Hermeneutics cycle by reflexive methodology; Source: Mometti (2023)

For each of the source of information, the hermeneutic reconstruction process was used, as represented in Figure 1 above. It involves a "back and forth" movement in the interpretative, enabling the identification of elements that contribute to the understanding the research objectives - in this case, how students in the last cycle of primary education represent certain astronomical elements. In the methodology used, this "back and forth" is referred to as the *alethic* process.

RESULTS AND DISCUSSIONS

Figures 2 and 3 below summarize some of the products created by students during the aforementioned Astronomy classes where the data for this study was collected.



Figure 2: Solar System construction - Student's group 1; Source: Research data (2024)



Figure 3: Solar System construction - Student's group 2, Source: Research data (2024)

As can be seen in Figures 2 and 3, both groups 1 and 2 of students built a model of the Solar System. This activity occurred after a sequence of five classes in which the teacher presented the following content: (i) Formation of the Solar System; (ii) Planets and their characteristics; (iii) the Sun and stars classification. For each of the content studied, the teacher used teaching materials produced by the company that supplies textbooks to the school. Thus, applying the alethic movement represented by Figure 1, it was possible to arrive at the first result of this study, which

showed that the students' media consumption on topics related to Astronomy greatly influences the way they construct their interpretations about the Solar System.

The finding was corroborated when both groups showed the teacher which videos they had already watched on the internet about the subject. It can be seen that the Solar System model of Group 1 is linear, while that of Group 2 is circular. This illustrates the different understandings of the distribution and organization of the planets around the Sun. However, it is worth highlighting that in the textbook used by the teacher depicted a linear model of the Solar System which likely demonstrated in Group 1's interpretation.

As a second result of the study revealed that although the teacher covered topics such as the emergence of the Solar System, including gas explosions, gravity, the students paid more attention to the Sun-Earth dyad during the constructions. This demonstrated a "concrete and realistic" perspective that they have of Astronomy.

Finally, it was observed that what was brought by the teaching material and what was presented by the class teacher made it impossible, during the observation period covered by this study, to promote an expansion of knowledge about Astronomy, leaving the students limited to a representation of the Solar System in a "flat" system, which is given by the papers on which it was constructed. In this sense, the Solar System model understood by the groups mirrors that presented in the teaching material, demonstrating both a pedagogical and epistemological limitation of these contents at this level of education.

CONCLUSIONS

From what was presented in this text, it can initially be concluded that in the group of 9th-grade primary school students, there was a tendency to reproduce, during Astronomy activities, elements concerning those already existing both in the teaching material used by the school and in teacher's instructions. Thus, during the period of collection and monitoring of the students, there were few opportunities to expand the knowledge being worked on.

In addition, it was observed that the consumption of different media forms by students, with videos shared on social networks being the most prominent, contributes significantly to the construction of what in this study define as "interpretation and construction of the model". This means that students construct their interpretations of astronomical elements, such as the Solar System, based on ideas conveyed by digital media that do not necessarily reflect accurate scientific knowledge.

It is concluded that the present work is part of a larger research project that has observed the teaching of Astronomy in Brazil, highlighting an urgent need to develop teaching materials that are grounded in validated scientific knowledge and didactic-pedagogical aspects of teaching that enable effective student learning.

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A SEVEN-PHASE PROFESSIONAL LEARNING MODEL FOR THE TRANSFORMATION OF EDUCATIONAL INSTITUTIONS TOWARDS A HYFLEX MODE

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ABSTRACT

This model proposes a seven-phase framework (S7) to develop, deliver, and evaluate professional learning for the transformation towards, and institutionalisation of, a HyFlex teaching, learning, and assessment environment within educational institutions. The framework consists of seven interrelated phases in which data is fed forward from each phase into the subsequent one. Forming a data continuum between each phase of the professional learning framework not only guards against discontinuity between the phases but also makes the framework adaptable and considerate to organisational context and complexity within each phase of the professional learning initiative. The seven (7) steps came out of the authors' 60+ years of cumulative experiences within educational organisations which led them to pinpoint that lack of a clear vision and strategy; lack of adequate technological infrastructure; lack of adequate training and support; resistance to change; cost; and cultural factors were key in hindering the successful institutionalisation of HyFlex learning within institutions. These seven phases are Substantiation, Space, Systems, Strategies, Skill, Systematic Scrutiny, and Strategic Sustainability.

Keywords: HyFlex teaching, hybrid flexible, blended teaching, educational technology, professional learning

INTRODUCTION

New models of instruction are necessary to support learners in multiple spaces and are influencing current technologies, strategies, and platforms trends. Traditional higher educations' use of digital and other spaces for teaching and learning is again transitioning. Whether used as a post Covid 19 suggestion (Kohnke & Moorhouse, 2021) to connect physical and virtual spaces (Leijon, 2016) and for increased enrolment (Sowell et al., 2023), greater flexibility (Howell, 2022), improved learner interaction (Leijon & Lundgren, 2019), or appropriate course design (Beatty, 2019) - higher educational institutions are embracing new educational models like HyFlex teaching.

DEFINING THE THEORETHICAL UNDERPINNINGS GUIDING THE PHASES

The HyFlex instructional approach is credited to having its genesis in the work of Dr Brian Beatty. Its design is to give learners greater control over their learning and course engagement modes. HyFlex allows students to choose in-person instruction or online instruction in real-time from a remote location (Beatty, 2010). It is also considered to be a curriculum design, that allows learners to choose between online asynchronous, online synchronous and face-to-face. Learner Choice provides participants with the agency to choose between any combination of modalities including face-to-face, asynchronous, or synchronous learning. HyFlex teaching is a viable option to blended teaching, in both traditional and non-traditional learning. HyFlex teaching refers to a flexible instructional approach that allows students to choose between attending classes in person, participating remotely in real-time, or accessing recorded sessions asynchronously, and with options to alternate between these positions at any time within the delivery of a course. This model offers learners the autonomy to select the mode of engagement that best suits their needs and circumstances (Milman, 2023).

Some key considerations to optimise this modality and facilitate good practice are accessibility, reusability, equivalency, technology, and cultural relevancy or appropriateness. Good practice for HyFlex teaching requires that learners of varying abilities and modalities, are able to access and use all the learning materials (Beatty, 2019). That is, all notes, lectures, artifacts, and materials, must be produced and stored for all learners' use and reuse (Milman, 2023). These materials ought to be of high quality to secure the course learning outcomes. Moreover, course materials must be of equivalent quality regardless of the mode of instruction in which the student decides to participate. The integration of technology and tools should be a seamless composite of face-to-face, synchronous, or asynchronous experiences regardless of the modality of learning and participation by which the student decides to access the course.

Cultural relevance and appropriateness of a HyFlex System refer to notions of culturally appropriate teaching strategies, resources, communications, and interactions based on the demographic represented in the learner group being taught. The instructor is required to include cultural responses and adaptations to technology that complement the needs of learners (Beatty, 2019; Howell, 2022; Howell et al., 2023).

FACTORS IMPEDING HYFLEX IMPLEMENTATION

HyFlex as an organisation's strategic initiative, (typically an expensive one both economically and culturally), is typically severely threatened by the following key factors:

Lack of Clear Vision and Strategy. Stakeholders within the organisation need to

be clear as to why HyFlex is important, how it will benefit the organisation, and how to implement it otherwise they will not participate, and the change will be unsuccessful (Nussli & Oh, 2024; Romero-Hall & Ripine, 2021).

Lack of Adequate Technological Infrastructure. Without proper infrastructure, members cannot participate in the HyFlex environment (Santandreu Calonge et al., 2023).

Lack of Adequate Training and Support. If they do not know how to participate, members cannot take advantage of the HyFlex system. Faculty and students especially must know how to use the HyFlex system (Boelens, Voet, & De Wever, 2018; Romero-Hall & Ripine, 2021).

Resistance to Change. Change is typically difficult and usurps the best organisational innovations that can propel institutions into greater efficiency and heights of success. Ensuring that all participants both understand the change and have the skills and knowledge to participate in the change is invaluable for the success of strategic goals and initiatives, including those involving HyFlex (Cumming, Gilanyi, & Han, 2024).

Cost. HyFlex environments can be expensive, and it becomes crucial to use the right strategies to grow organisational skills so that on the ground systems and spaces are maximised. Moreover, it is important that organisations protect their economic and cultural investments through processes that secure the digital transformation required to institutionalise HyFlex (Bond et al., 2021).

Cultural Factors. Resistant cultural factors include weak leadership, lack of resources, and resistance to change. Cultures within the organisation that can impede HyFlex need to be mitigated, especially if the organisation has previously enjoyed success with a strong focus on traditional, face to face educational services (Mobo & Garcia, 2023; Nussli & Oh, 2024).

Out of this Figaro-Henry and Boisselle propose a seven-step (S7) professional learning framework. The exact details within each phase of the framework is customised from the results of a HyFlex

pre-needs questionnaire as well as face to face interviews with stakeholders initiating the change at the organisation.

The seven (7) phases of the professional learning framework target can give Hyflex adopters a useful roadmap to institutionalise HyFlex. The S7 model is below:

Phase 1: Substantiation

Determination of the organisational and contextual requirements to implement and establish an efficient and successful HyFlex environment. The validation of HyFlex as a digital transformation incorporating both digitisation and digitalisation.

Phase 2: Space

The creation and establishment of the physical spaces needed for the organisation to run seamlessly in HyFlex mode. In the S7 model physical space embraces the general environment of all buildings, administrative spaces, general learning spaces, assessment spaces, specialised subject matter spaces such as laboratories, and support staff spaces as well as the attendant equipment and materials.

Phase 3: Systems

Installation of strategic plans, policies, procedures, programs, and necessary supportive software commitments. Systems considered include instructional, professional development, evaluation and assessment, administrative, support, technological, and technical systems.

Phase 4: Strategies

Mastery of the use of organisational space and systems to create an efficient and seamlessly functioning HyFlex environment. These include existing strategies and new strategies needed to institutionalise a HyFlex environment.

Phase 5: Skill

Integration of Space, Systems, & Strategies to provide a HyFlex environment for equity and equality of face-to-face and online educational experiences.

Phase 6: Systematic Scrutiny

Using Kirkpatrick (1993) and Kirkpatrick & Kirkpatrick (2016) model(s) of evaluation, to validate professional learning within all systems (administrative systems, instructional systems, professional development systems, evaluation and assessment systems, support systems, technological systems, technological systems)

Phase 7: Strategic Sustainability

Creation and prescription of a summarised list of sustainability steps for HyFlex system preservation.

CONCLUSIONS

The Seven-Phase Professional Learning Model (S7) gives a comprehensive framework to guide educational institutions in their transformation towards a HyFlex environment. A HyFlex learning environment ensures equity across different modes of delivery, highlighting the principles of accessibility, reusability, and equivalency.

The principles in the S7 model necessitate a holistic integration of physical, digital, and pedagogical spaces to create a seamless learning experience. The S7 model also offers iterative feedback loops with data collection and analysis occurring at each phase, which permits for refinement and contextual customisation.

The S7 model will prove its robustness but will typically face challenges when used to transform an organisation to HyFlex in terms of institutional resistance, resource limitations, and variability in stakeholders' willingness to support the organisational shift to HyFlex. Still, the S7 is a strategic roadmap that not only addresses immediate operational challenges but also ensures long-term viability through systematic scrutiny and sustainability planning.

Theoretically, the S7 model enriches the discourse on digital transformation in education by providing a structured approach to overcoming common barriers. Practically, it offers institutions a scalable, adaptable model that aligns with their educational demands, and which can enhance learner autonomy and engagement.

Still, the S7 is a strategic roadmap that not only addresses immediate operational challenges but also ensures long-term viability through systematic scrutiny and sustainability planning.

In conclusion, the transformation to a HyFlex environment is not merely a technological upgrade but a paradigm shifts in educational delivery. The S7 framework equips institutions with the necessary tools and strategies to navigate this shift effectively, fostering resilient, flexible, and inclusive learning environments.

RECOMMENDATIONS

Intentionally thinking and planning about how HyFlex is to be implemented, will positively affect the transitioning institution. Learning the tools, researching the process, analysing the infrastructure, are strategies for future success. Coordinating the planning activities in line with the institution's mission and vision will guaranty alignment of strategic objectives and improve learners' experiences.

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ENHANCING DESIGN THINKING THROUGH I-STEM

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ABSTRACT

This study explores the impact of a STEM didactic sequence on students' design thinking skills. Using a qualitative approach, it analyses how 30 12th-grade students engaged with design thinking phases— Problem definition, Brainstorming, Design and Construction, Evaluation, and Redesign—while addressing a real-world problem of indoor air quality. Divided into five groups, students created technological devices to monitor CO₂ levels in school spaces, integrating Science, Technology, and Engineering through hands-on, problem-based learning. Findings reveal diverse, creative approaches among groups, demonstrating design thinking's adaptability and fostering resilience, creativity, and practical problem-solving. The study highlights the benefits of integrating design thinking into STEM education, showing its effectiveness in enhancing students' engagement and interdisciplinary learning. The research supports the broader adoption of design thinking within STEM curricula to prepare students for complex, real-world challenges.

Keywords: Design Thinking in STEM Education, Problem-Based Learning, Interdisciplinary Engagement

INTRODUCTION

The acronym STEM (Science, Technology, Engineering, and Mathematics) was introduced by the National Science Foundation (NSF) in the late 1990s, emerging from a growing interest in promoting education in these fields to drive technological innovation and enhance economic competitiveness (Bybee, 2013). STEM's historical context is linked to the push for science and technology that began in the 1950s, motivated by the Soviet Union's launch of Sputnik. This event led to substantial investments in the United States' educational system and scientific research, aiming to increase the country's capacity for innovation and ensure its technological leadership in the face of the challenges posed by the space race (Develaki, 2020; Breiner et al., 2012). Despite these efforts, challenges such as limited student interest in STEM careers, difficulties in integrating STEM disciplines, and the perception of these subjects as complex and inaccessible have persisted (Bybee, 2013; Sanders, 2009; Wang, 2013; Archer, Dewitt, Osborne, Dillon, & Willis, 2010).

Considering these limitations and the need to prepare students with skills applicable to increasingly complex and innovative contexts (Millar, 2020), a reassessment of STEM education strategies became necessary. This led to educational reforms worldwide, including the introduction of the Next Generation Science Standards (NGSS), which integrate engineering practices into science curricula (NGSS Lead States, 2013). These reforms underscored that STEM education should extend beyond traditional disciplinary boundaries, advocating for a more practical and interdisciplinary approach that equips students to tackle real-world challenges. Within this framework, a distinction has been proposed between 'STEM,' which refers to the teaching of individual disciplines, and 'I-STEM,' which emphasizes the integrated teaching of two or more disciplines, fostering connections between content areas to solve real-world problems (McComas & Burgin, 2020; Moore et al., 2014; Breiner et al., 2012). This integrated approach (I-STEM), aligned with pedagogical practices like problem-based, inquiry-based, and cooperative learning, makes education more engaging and relevant (Bybee, 2013; National Research Council, 2014).

In this context, design thinking—a reflective and creative problem-solving methodology emerges as a critical component of integrated STEM education (Li et al., 2019). Design thinking emphasizes iterative processes such as problem identification, brainstorming, prototyping, testing, and refinement (Simarro & Couso, 2021). Originally associated with fields like architecture and engineering, design thinking has increasingly influenced the integration of engineering practices into education, particularly within science curricula (National Research Council, 2012). It offers a holistic approach to learning that fosters both the analytical skills central to scientific inquiry and the creative problem-solving skills inherent to engineering (Owen, 2007). This approach enhances critical thinking, creativity, and practical problem- solving, making STEM education more relevant and effective in addressing real-world challenges (Pleasants, 2020; Li et al., 2019; English & King, 2015).

METHODOLOGY

The study employed a qualitative approach to analyse the development of students' design thinking skills and how these skills contribute to their engagement and learning when involved in a STEM didactic sequence. The research focused on identifying, describing, and analysing the different stages of design thinking that each student group experienced throughout the implementation of the didactic proposal. By examining each phase—Problem Definition, Brainstorming, Design and Construction, Evaluation, and Redesign—the study aimed to capture how students engaged with the design thinking process and applied their STEM knowledge in real-world contexts.

The research was conducted with a class of 30 12th-grade students from the Sciences and Arts, who were divided into five mixed groups. The didactic sequence was designed to integrate STEM disciplines—Science, Technology, and Engineering—through hands-on, problem-based learning guided by the principles of design thinking. Students were tasked with addressing a real-world problem related to environmental sustainability, specifically focusing on monitoring air quality within school spaces. They were required to design a technological device capable of measuring and monitoring carbon dioxide (CO₂) levels indoors, providing a contextually rich experience that allowed them to apply scientific knowledge and technological skills in a meaningful and practical manner.

To analyse how students engaged with the STEM didactic sequence, multiple data collection methods were employed, including written productions, direct observation, and photographs. The content analysis of the data enabled a comprehensive and triangulated examination, ensuring a deeper understanding of the findings from multiple perspectives. Written productions offered insights into students' understanding and reflective processes, while direct and indirect observations captured real-time interactions, students' engagement and collaboration in the classroom. Photographs documented the development of prototypes, providing visual evidence of the students' creative, interdisciplinary learning and problem- solving processes.

The first phase, Problem Definition and Scoping, involved students identifying the issue of indoor air quality and gathering information about safe CO_2 threshold levels. This phase highlighted the importance of understanding air quality's impact on health and learning conditions, laying the groundwork for their design challenges. The second phase, Brainstorming, consisted of collaborative ideation sessions where students discussed potential solutions and generated innovative ideas for their technological devices. This phase fostered creativity and encouraged students to explore various design possibilities.

During the design and construction phase, students learned to program and use a micro: bit and a CO_2 sensor, integrating these technologies into their prototypes. This phase required students to construct devices capable of measuring CO_2 levels and providing real-time feedback based on collected data, enabling them to apply their technological and programming skills directly. In the

Design Evaluation phase, students tested their prototypes in various areas of the school, assessing the accuracy and functionality of their CO_2 measurements. This evaluation involved data analysis and interpretation of results to determine the effectiveness of their designs in real-world conditions.

Throughout the didactic sequence, students engaged in problem-solving activities that required them to apply scientific knowledge, technological skills, and engineering principles in a collaborative setting.

RESULTS AND DISCUSSION

A content analysis was conducted based on the design thinking framework to categorize data and collect evidence gathered from each group's work. This approach allowed researchers to systematically map students' creative processes onto the distinct stages of design thinking, revealing the diverse pathways each group followed not only fostered creativity and problem-solving in STEMeducation, but also catalyzed student engagement and interdisciplinary learning. For example, Group 1 focused on creating a robust and portable air quality monitoring prototype. They developed a spaceship-shaped device using a traffic light system to indicate CO₂ levels, making it more complex and visually appealing.

Group 2 initially designed a cloud-shaped prototype to represent air quality but, after iterative testing, transitioned to a tree-shaped design symbolizing environmental health and air purification. Despite encountering challenges and requiring multiple iterations, the group refined their design by focusing on key aspects related to environmental sustainability and well-being.

Group 3 engaged in the creation of a cigarette pack-shaped prototype to raise awareness about the effects of smoking on indoor air pollution. This design effectively communicated the negative impact of smoking on air quality, serving as a powerful educational tool.

Group 4 explored air quality through a television-shaped prototype as a means of disseminating information on the topic. They incorporated a push button to light up the "TV," enhancing interactivity. Additionally, they programmed components for sound alerts and customized sensor displays related to air quality. This innovative approach revealed their learning in the areas of environmental awareness and well-being, as well as in new technologies, demonstrating a willingness to integrate these elements and push beyond the initial learning objectives.

Group 5 created a greenhouse-shaped prototype highlighting plants' role in air purification. The prototype used auditory alerts identifying when the sensor was reading CO_2 levels. An opening roof allowed users to view the readings, reinforcing the connection between environmental conditions and air quality. The group emphasized the use of sustainable materials and creatively adapted their design to overcome construction challenges.

Throughout the design thinking process, groups frequently revisited and revised earlier stages, illustrating the methodology's iterative and non-linear nature. This cycle of testing, feedback, and refinement required groups to return to stages such as ideation and prototyping, embracing setbacks as opportunities for deeper learning and creative exploration, such exploration would have been difficult without their active engagement. Additionally, the iterative process encouraged the studentsto explore topics related to CO_2 monitoring in greater depth.

CONCLUSION

The results of this study suggest that design thinking not only engages students with STEM disciplines but also fosters essential skills such as resilience, adaptability, and innovative problem-solving. By addressing meaningful, real-world problems, students can connect theoretical knowledge with practical applications, thereby enhancing their motivation and understanding of STEM concepts. The iterative nature of design thinking encourages students to view challenges as integral components of the learning process, promoting a mindset of continuous improvement and creative exploration.

This study highlights that STEM didactic sequences can significantly influence students' design thinking processes, encouraging diverse approaches to problem-solving and increasing engagement with STEM content. Design thinking cultivates an innovative mindset, enabling students to explore multiple solutions, refine their ideas through continuous feedback, and apply their knowledge in dynamic ways. The findings emphasize the value of integrating design thinking into STEM education as a critical component that promotes interdisciplinary learning and raises students' awareness of the complexities of real-world problems, while also highlighting the role of technology in the modern world.

As education systems continue to evolve, incorporating design thinking into STEM curricula presents a promising way for develop the skills and mindsets necessary in an increasingly interconnected and complex global environment.

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INTEGRATED STEAM EDUCATION FOR STUDENTS' CREATIVITY DEVELOPMENT

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ABSTRACT

This study aims to explore how a learning sequence designed with an Integrated STEAM Education perspective (iSTEAM) contributes to students' levels of creativity. The participants in this study were students from 9th and 10th grade with ages between 14 and 16 years old. Students were challenged to produce a soundtrack for an animation video. This was achieved by building artifacts and using the phenomena of physics under study (mechanical energy) to produce sound effects. These were later digitally recorded and assembled to build the video's soundtrack. This research work contributes to addressing the importance of STEAM education integration and of digital competence in developing students' creativity in problem solving.

Keywords: STEAM education, STEAM integration, creativity development, digital competence, problem solving.

INTRODUCTION

As the 21st century advances, an increase in challenges associated with the sustainability of the planet and the advancement of technology is expected. This implies a significant growth of professions in areas associated with sciences, mathematics, engineering, and technology. To be able to find solutions to those challenges, qualified professionals in these areas will be required. These professionals will be required to use acquired skills and attitudes (as students, citizens, and professionals), such as the resolution of multidisciplinary problems, critical thinking, collaboration, and creativity. No less important is the aim that even citizens who do not occupy these professions be scientifically literate, so that they can respond as active citizens to these challenges. Guiding documents from different countries reinforce the importance of developing STEM (Science, Technology, Engineering, and Mathematics) areas in education and investment.

STEM education is presented by several authors with various interpretations, from which STEAM (Science, Technology, Engineering, Arts, and Mathematics) education derives (Yakman, 2008). Quigley and Herro (2016) extended Yakman's STEAM definition to iSTEAM education, as a transdisciplinary approach that aims to solve real-world problems. For other authors, iSTEAM is viewed as a way to better blend the different disciplines so that students can develop specific skills and attitudes, such as creativity, critical thinking, and an innovative mindset (Boy, 2013). Creativity is a skill that cuts across several disciplines, having a prominent and pertinent role in the context of STEAM Education (Boy, 2013). There is a shortage of studies that correlate STEAM (and iSTEAM) with creativity development (Aguilera & Ortiz-Revilla, 2021). Furthermore, the association of STEAM education with digital competences is scarce and even more so if we exclude programming as a digital competence, or visual arts/design as the art included in STEAM activities. Taking these considerations into account, this study aims to shed light on students' creativity development while performing iSTEAM tasks that involve production, digital recording, and assembly of sound effects to produce a video soundtrack. The sound effects were created using physical phenomena associated with mechanical energy.

Specifically, our study aimed to understand the effect of iSTEAM education on the development of competences associated with creativity. Since these tasks involve the use and development of digital
competences as well, this study aims also to understand if the latter could also contribute to creativity development by students. Therefore, the following research question (RQ) guided the study: RQ: Can iSTEAM education didactic tasks contribute to student levels of creativity while using digital competences?

METHODOLOGY

This study involved the participation of forty-nine students with ages between 14 and 16 years old. These students performed iSTEAM activities in the context of learning about "Energy" domains (e.g., energy forms and transformations, free fall, inclined plane, etc.) in Physics class from two different and consecutive grade levels. Specifically, the iSTEAM tasks comprised three distinct phases: (a) introduction and exploratory phase, (b) construction of the final artefact(s), and (c) digital recording and assembly.

This is a qualitative and interpretative study which included data collection from participant observation, namely using field notes that were written at the end of each class, when the iSTEAM tasks were performed by students and later transcribed and categorised. During the activities, i.e., during classes, the first author took photographs and videos of the artefacts and of the screenshots of the video editing program in remote Zoom class (DaVinci Resolve). Each student also performed written records during activities (drawing schemes, writing procedures, observations, and reflections) that were collected by the teacher at the end of each task.

The analysis of these results is based on a selection of criteria associated with monitoring the development of creativity in students already described in the literature (Thuneberg, Salmi, & Bogner, 2018). In agreement with these authors, these criteria dimensions were divided into "Act" and "Flow", briefly described as follows:

- "Act"—incorporation of an already-used solution in a new way; bringing together unrelated concepts to create an idea/solution; creating a connection between the proposed problem and a related situation; approaching the problem from different perspectives to find a solution; attempting to think/imagine several solutions to solve a problem (not immediately accepting the first solution).
- "Flow"—immersion in problem solving; feeling of effortless work; proactivity and communication of ideas.

RESULTS AND DISCUSSIONS

The work developed by students during iSTEAM tasks went from creating simple to complex artefacts. With the latter, students produced sound effects that could be used in the production of the soundtrack for animated videos lasting between one and two minutes.

In addition to the creativity associated with the exploration of sound effects, the students' creativity was also analysed in the choice of moments in the video at which the sound effect would be placed, regarding the relevance of its visual or scripted context. Although the students made a written record of the time intervals with which each sound effect would be associated, some digital changes were made later at the students' request after viewing the result of the assembly. These changes occurred when students remotely followed the audio files' assembly to the video images, in group by group Zoom sessions.

The analysis of the data collected through the previously described instruments, in material and methods, allowed for the assessment of students' creativity levels, considering several dimensions in group-based analysis. With these results, it is possible to observe that the iSTEAM tasks, performed

with students' workgroups, were able to develop their creativity in several dimensions. These results can be observed in Table 1.

Table 1. Assessment rubric for groups of students for creativity levels associated with Act (I, IIa andIIb) and Flow (III and IV). The number of groups assessed in each category are highlighted in bold.Extra details and examples can be observed in the original article as referenced Filipe, Baptista &Conceição (2024)

Evidence Dimension	Insufficient	Sufficient	Good	Excellent
I. Incorporation of a solution previously used in a new way; approach to the problem from different perspectives to find a solution.	0 groups : The students remained in the initial structure of the artefact, not exploring different options.	5 groups : The students remained in the initial structure of the artefact but tested some options.	4 groups : The students changed their initial artefact to match what was intended, with some exploration of the different options.	3 groups : The students changed their initial artefact to match what was intended, exploring diverse options in detail.
IIa. (in artefact construction) : Creation of a connection between the proposed problem and a related situation; attempt to think/imagine several solutions to solve a problem (do not immediately accept the 1 ^a solution); junction of unrelated concepts to create an idea/solution.	0 groups : The students were unable to use the physics phenomena under study to solve the proposed problems.	3 groups : The students were able to use the phenomena of physics under study to solve the proposed problems, but immediately accepted the first solution.	8 groups : The students were able to use the phenomena of physics under study to solve the proposed problems, testing several solutions.	1 groups : The students were able to use the phenomena of physics under study to solve the proposed problems, testing several solutions, obtaining diversity, and overcoming relevant difficulties in relation to the desired sound effects.
IIb. (in digital assembly of the soundtrack of the video): Creation of a connection between the proposed problem and a related situation; attempt to think/imagine several solutions to solve a problem (do not immediately accept the 1 ^a solution); junction of unrelated concepts to create an idea/solution.	0 groups : The students were unable to listen and select coherent and pertinent sound effects from the audio files for the intended parts of the video.	5 groups : The students were able to listen and select coherent and pertinent sound effects from the audio files for the intended parts of the video but were satisfied with their first chosen option of placement and did not request additional digital alterations.	5 groups : The students were able to listen and select the sound effects from the audio files for the intended parts of the video, and after testing their first chosen option of placement, chose different placements, duplication, overlaps, or requested additional digital alterations.	2 groups : The students were able to listen and select the sound effects from the audio files for the intended parts of the video, and after testing their first chosen option of placement, chose different placements, duplication, overlaps, requested additional digital alterations and still wanted to improve the artefact construction to produce and record improved sound effects.
III. Immersion in the resolution of the problem; feeling of effortless work.	0 groups : The students were not committed to solving the problems.	2 groups : The students showed commitment to solving the problems but perceiving the passage of class time.	10 groups : The students showed commitment to solving the problems, not noticing the passage of class time.	0 groups : The students showed commitment to solving the problems, not noticing the passage of class time. The students worked on the construction of the artefact outside

				of school time.
IV. Proactivity and communication of ideas to peers.	0 groups : Students do not present relevant ideas, or refuse to work, even when oriented in that direction.	2 groups : Students present some relevant ideas, working only when oriented in that direction.	5 groups : Students present useful and relevant ideas, working actively, yet with poor time management.	5 groups : Students present useful and relevant ideas, actively working in the time available, and encouraging the participation of all for the application of their ideas.

More specifically, considering the "Act" dimension, iSTEAM tasks positively influenced the development of creativity in students regarding incorporation of ideas previously used into new solutions or finding solutions by approaching a problem from different perspectives. In the latter, a slight majority of groups could achieve good or excellent levels (58%). While constructing the final artefacts and digitally assembling the soundtrack, the results were also very positive regarding students' ability to connect the proposed problems to a related situation previously experienced, allowing them to explore several solutions and to find new ideas by blending unrelated concepts. For these criteria, 75% and 58% of groups could obtain a good or an excellent level during final artefact construction and digital assembly, respectively.

Considering the dimensions related to "Flow" the students' motivation and group environment to perform creative work, a more expressive majority of groups, 83%, attained good and excellent levels. These values were obtained while evaluating students' immersion in problem solving and the observed proactivity and communication during teamwork, respectively.

This research aimed to contribute to increasing the existing knowledge on iSTEAM education regarding students' creativity, since it is scarce and many gaps remain to be explored (Aguilera & Ortiz-Revilla, 2021). More specifically, this study sought to examine the impact of didactic iSTEAM tasks on the development of students' creativity levels while also using digital competences, as stated in the research question. It is hoped that the findings of this study could contribute to reinforcing iSTEAM education as a student-centred approach where teamwork, problem-solving skills, and creativity levels can be developed. The existing literature is concordant with our findings, wherein it is suggested that STEAM education aims to enhance and develop creativity, maintaining the focus on student-centred learning, where students investigate, communicate, and solve problems (Quigley and Herro, 2016). It is agreed with Toma and Greca (2018) that STEAM education can be a more effective methodology to address problems and find solutions while a positive attitude and motivation are maintained by students. The integration of arts into STEM disciplines is emphasised in our work, with the arts serving as a critical component in achieving creative goals, such as producing a synchronised video soundtrack with hands-on student-centred tasks. This created an environment conducive to integration across disciplines, with students actively involved in their learning processes, reinforcing that creativity is a skill that can be cultivated in all students, in agreement Connor, Karmokar, and Whittington (2015).

Additionally, the complexity of the iSTEAM tasks required students to engage in advanced problemsolving, particularly in synchronising sound with visual media. This complexity not only facilitated creativity but also encouraged the development of various skills relevant to the sciences as previously addressed by Boy (2013). The integration of digital competencies was crucial for achieving the project goals, showcasing the effectiveness of iSTEAM tasks in bridging disciplinary boundaries and enhancing student engagement and creativity.

CONCLUSIONS

In conclusion, it can be stated that the iSTEAM didactic tasks allowed students to develop creativity while using digital competence. Competences associated with creativity and digital competence will be fundamental in the 21st century, and this work could contribute to reinforcing integrated STEAM education as an effective methodology to develop these competences in students.

The main limitations of this study are related to the number of participants and the specificity of the age interval considered. It is acknowledged that the iSTEAM tasks could be adapted to other ages and other curriculum grades, and that could be a subject of further studies. Additionally, it would be interesting to investigate this type of approach in terms of the teacher's perspective, considering some general misconceptions regarding creativity development in students and in science subjects.

Finally, this study contributed to highlighting STEAM education in relation to STEM education, having allowed the arts to be a factor introducing complexity into the problems that students had to solve. This complexity has led students to develop not only their knowledge associated with the domain of energy, but also their creativity and digital skills, as well as transversal skills to the experimental and exact sciences.

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ANALYSING ELEMENTARY SCHOOL TEACHERS' TECHNOLOGICAL PEDAGOGICAL CONTENT KNOWLEDGE (TPACK) THROUGH LESSON PLANS AND DEMOS

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ABSTRACT

This study aims to analyse the profile of technological pedagogical content knowledge (TPACK) for elementary school teachers through lesson plans and demos. The data was collected from 12 in-service elementary Central Board of Secondary Education (CBSE) schoolteachers. In this study, the researchers qualitatively analysed lesson plans and demos of core subjects like English, Maths, Science, and Social Science. Equally, demos of teachers teaching in elementary level were observed. Based on the analysis of the lesson plans and demos, the researchers found that: i) Lesson plans were not appropriate, and application of technology related to the content pedagogy were lacking behind. This study found that teachers were not having the knowledge of integrating technology, pedagogy and content knowledge in their lesson plans. ii) The lesson plans lacked the application of basic competencies which were needed in this 21st century era. The result of the study indicated that the ability of TPACK from elementary school teachers can be developed by continuous professional development programs on TPACK and arranging hands-on activities on 21st century skills.

Keywords: TPACK, Lesson Plan, Elementary School Teachers, 21st century teaching skills,

INTRODUCTION

The 21st century is all about skill development, integration of technology, lateral thinking, creativity, judgement, higher order skills like reasoning and analysis and teaching needs to serve to discourage rote memorisation. According to Nessipbayeva (2012), 21st century teachers should learn effective classroom management, effective teaching practices, effective assessment, and technology skills. As technology continues to spread in every part of our lives, utilising it effectively to promote efficient educational practices is more crucial than ever. While educational technology is available in classrooms in some form or other, it is not always up-to-date or utilised correctly.

TPACK Framework

The Technological Pedagogical Content Knowledge (TPACK) framework is an educational model that describes the intersections between technology, pedagogy, and content for the effective integration of technology into teaching. This TPACK framework was first introduced by Punya Mishra and Matthew J. Koehler of Michigan State University in 2006. This framework is to understand how to use technology to teach concepts in a way that enhances students' learning experiences. It helps to deliver the students via using various teaching materials. This framework is an adequate display of enhancing the teaching and learning experience. In short, TPACK attempts to identify the nature of knowledge required by teachers for technology integration in their teaching while addressing the complex, multifaceted, and situated nature of teachers' knowledge.



Figure 1. Technological Pedagogical Content Knowledge (Koehler & Mishra, 2009)

There are seven (7) components addressed in the TPACK framework: Technology Knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Pedagogical Knowledge, and Technological Pedagogical Content Knowledge. Undoubtedly, it encourages a deeper understanding of how technology can be used to improve pedagogical practices and students' learning. The Technological Pedagogical Content Knowledge framework is a versatile tool that can help instructors to integrate EdTech in their classrooms. It highlights how an educator's knowledge impacts students' learning outcomes while providing a tech-friendly approach to organising curricula. In short, TPACK outlines a point of reference for utilising technology thoughtfully and effectively. Through the many intersections of the three components—technology, pedagogy, and content—instructors can implement this framework and use their existing knowledge to deliver excellent learning experiences (Koehler, Mishra, Akcaoglu & Rosenberg, 2016).

Lesson Plans

Lesson plans are a framework for teachers to reflect in a deeper and more creative way about how to design and structure activities for different students and help achieve constructive alignment between theory and practice. It is the best way to deliver an effective and engaging lesson. It also helps to keep teachers on track to ensure the learners reach their goals and targets in line with the course curriculum. A lesson plan is an important part of instruction that consists of some aspects, such as goals, objectives, activities, media, learning outcomes, pedagogy and assessments (Sesiorina, 2014). Cai & Wong (2007) suggested that in terms of analysing the lesson plan, both content and process are very essential aspects of the lesson plan. These two aspects have to be sequentially one and another in order to create effective lesson plans.

NEP2020

The New Education Policy-2020 has introduced many reformations in the Indian education system. NEP-2020 vision and mission of teacher education and based on personal teaching experience, the researchers undertook this study. We tried to analyse the profile of technological pedagogical content knowledge (TPACK) for elementary school teachers through lesson plans and demos. Literature on

continuing professional development (CPD) revealed that there is a need to keep teachers' professional knowledge and TPACK skills updated. For effective CPD there is a need to study and develop a teacher training module to fulfil the 21st century competencies and TPACK skills for teachers. According to Kereluik, Mishra & Koehler (2010) the development of TPACK should begin with relatively familiar technologies which teachers may have already developed TPACK, and to gradually progress to those that are more advanced.

RESEARCH AIMS AND RESEARCH OBJECTIVES

The principal aim of this study was to analyse the lesson plans and demos of teachers to explore the technological pedagogical content knowledge (TPACK). In this study, the researchers focused on the following research questions :

- 1. What are the technological pedagogical content knowledge (TPACK) skills elementary school teachers included in their lesson plans?
- 2. What are the technological pedagogical content knowledge (TPACK) skills elementary school teachers highlighted in their demos?
- 3. What are the perceptions of elementary school teachers regarding the technological pedagogical content knowledge (TPACK) skills?
- 4. What are the different technological pedagogical content knowledge (TPACK) strategies listed by elementary teachers in their lesson plans and used in demos?

RESEARCH METHODOLOGY

The present study employed qualitative research and applied descriptive study as a framework. According to Bogdan and Biklen (2006), qualitative research provides actual settings as the direct source of data and descriptive study views that everything has the potential to provide a clue that reveals more comprehensive understanding.

Participants

In this study, the researchers qualitatively analysed ten lesson plans of core subjects like English, Maths, Science, Social Science and ten demos of teachers teaching in elementary level were observed. Purposive sampling method was applied. Lesson plans were collected from 12 Central Board of Secondary Education (CBSE) elementary school female teachers. According to the norms of CBSE board, all teachers were graduates or postgraduates with B.Ed degree. They all had an average teaching experience in primary school for 3 to 5 years. Two lesson plans for each subject were analysed.

Instrument and Procedures

All twelve lesson plans were first critically gone through and graded. Then, the same teachers' demos were observed and graded on the observation sheet. As mentioned earlier, this study focused on TPACK of elementary school teachers through lesson plans and demos.

Data Analysis

Apart from hands-on activities, elementary teachers integrated various technologies in their lesson plans and demos for core subjects like English, Maths, Science and Social Science. For the qualitative analysis of lesson plan and demos, seven components of the TPACK framework: Technology Knowledge, Content Knowledge, Pedagogical Knowledge, Pedagogical Content Knowledge, Technological Content Knowledge, Technological Pedagogical Knowledge, and Technological Pedagogical Content Knowledge lens were considered.

RESULTS AND DISCUSSION

Detailed analyses of these lesson plans and demos are consolidated in the following tables :

Teacher	Class	Subject	Торіс	Information	Media	Technology
					(Teaching Matorials)	
1	3	Social Science	The Western Desert	i)Kinds of deserts, sand storm, sand dunes, ii)Location ,Climate Vegetation	Images, Documentaries of deserts	Tata classedge econtent
2	4	Maths	Time	i) Importance of Time ii) Different ways to measure time.	Clock Model	Interactive Panel
3	5	Social Science	Natural Resources	i) Differences between renewable and non- renewable resources ii)Importance of natural resources	Images documentaries	Tata classedge and Cordova econtent
4	6	Science	Soil	i) How soil is formedii) Importance of soil	samples of soil,	econtent of Tataclassedge and cordova through interactive panel
5	5	English	Naming words	changing words from singular to plural	images	Interactive panel
6	6	Maths	Playing with Numbers	i) Prime and composite numbers ii) Factors and Multiples	Videos	econtent of Tataclassedge and cordova through interactive panel content
7	5	English	Poem:Run	Importance of travel and Physical Activities	referring images given in the book	nil
8	4	English	Grammar: pronouns	 i) defining and identifying the pronouns ii) Types of pronouns 	Textbooks, workbooks	Interactive panel for quiz
9	5	Maths	Square	i) Perimeter and Area of the square	Textbook activities	Interactive panel
10	7	Maths	Triangles and its properties	Measure the triangle using angle sum property	Activity from textbook, video	Interactive panel for videos,
11	7	Science	Acids, Bases and Salts	 i) Identifying acids and bases by different indicators ii)comparison the properties of acids and bases 	Textbook, Videos, Quiz	Youtube Videos, quiz using smart board

 Table 1 : Details of lesson plans & demos

Discussion of Table No. 1

Lesson plans from 12 in-service elementary teachers working in a CBSE school are analysed. Demos from the same teachers were observed by the researchers. The main content areas addressed are English, Maths, Science, and Social Studies. The table illustrates the selected content, information about the content and technology, as well as the pedagogy opted for the teaching process.

Discussion of Table No. 2

Table 2 below shows the analysis of lesson plans and demos as per the TPACK components. The review of lesson plans and demos describes the various pedagogies and technologies that are integrated in teaching the students as per the content and the level of the students. After reviewing the lesson plans and observing the demos, few lesson plans do not show the proper integration of combination of all the seven domains, TK, PK, CK, TPK, TCK, PCK, and TPACK is appropriately integrated and used in the lesson plans for an effective teaching and learning process (Mishra & Koehler, 2009).

The focus of this study was on whether teachers use technological devices through the appropriate pedagogical approach rather than on how frequently they use such devices. It also examined how well teachers were experienced in selecting and integrating all the components of TPACK. The need for pedagogical knowledge should be brought into prominence in teacher education and professional development programs. From the above analysis, a CPD program is required to train the teachers on creating TPACK lesson plans and implementing them in their teaching and learning process to acquire the competencies of 21st century skills and also to align with the education system of NEP 2020. Applying TPACK to the task of teaching with technology requires a context-bound understanding of technology, where technologies may be chosen and repurposed to fit the very specific pedagogical and content-related needs of diverse educational contexts (Kereluik, Mishra, & Koehler, 2010).

	Table 2: TPACK Components								
Sr.NO	Class	Subject	ТК	РК	CK	ТСК	ТРК	РСК	TPACK
1	3	Social Science	Applies Technical skills	Uses PK effectively	Have a sufficient knowledge of the content	relates the content and technology appropriately	Chooses the appropriate technology as per the	Effective teaching approach	combining content, technologies and teaching approaches in their teaching
2	4	Maths	nil	appropriate teaching strategies were used	age appropriate content is used	specific content and technology integrated	nil	Selects appropriate and effective teaching strategies	Technology is not included in teaching
3	4	English	uses digital screen for the assessment only	assessing student using technology	develops class activities	develop class activities using technology	using area specific computer applications	Developing evaluation tests for specific content	Teaching content with different instructional strategies
4	5	Science	Uses a digital content	uses appropriate methods	develops class activities	uses area specific computer applications	chooses technology appropriate for teaching	Prepares a lesson plan including various activities	combines successfully technology, pedagogy and content
5	5	English	unable to use	uses lecture method	follows the textbooks	not able to integrate	unable to use	except technology	integrates content and

Table 2: TPACK Components

-										-
				technology			technology	technology as per the content	selects other methods	pedagogy only
	6	5	Maths	Appropriate technology is selected to enhance learning	develops various methods for assessments	develop appropriate class activities	chooses technology for teaching learning	uses area specific computer applications	Selects appropriate and effective teaching strategies	Technology is integrated with content and pedagogy
	7	5	Social science	Uses area specific e content	approaches with different teaching theories	knows the key content areas	uses technology for instructions	selects appropriate and teaching strategies using technology	Effective teaching approach	combining content, technologies and teaching approaches in their teaching
	8	6	Maths	Applies Technical skills	aware of possible learning difficulties	develops appropriate class activities	relates the content and technology appropriately	Chooses the appropriate technology as per the	Effective teaching approach	combining content, technologies and teaching approaches in their teaching
	9	6	Science	Uses area specific e content	approaches with different teaching theories	knows the key content areas	uses technology for instructions	selects appropriate and teaching strategies using technology	Effective teaching approach	combining content, technologies and teaching approaches in their teaching
	10	7	Maths	Uses area specific e content	approaches with different teaching theories	knows the key content areas	uses technology for instructions	selects appropriate and teaching strategies using technology	Effective teaching approach	combining content, technologies and teaching approaches in their teaching
	11	7	Science	Uses a digital content	uses appropriate methods	develops class activities	uses area specific computer applications	chooses technology appropriate for teaching	Prepares a lesson plan including various activities	combines successfully technology, pedagogy and content
	12	7	Social Science	Uses area specific e content	approaches with different teaching theories	knows the key content areas	uses technology for instructions	selects appropriate and teaching strategies using technology	Effective teaching approach	combining content, technologies and teaching approaches in their teaching

CONCLUSIONS

The conclusion made from this study includes:

a. Based on the analysis of the lesson plans and demos, the researchers observed that: i) lesson plans were not appropriate and application of technology related to the content pedagogy were lacking behind, ii) teachers were not having the knowledge of integrating technology, pedagogy and content knowledge in their lesson plans, iii) the lesson plans lacked the application of basic competencies which were needed in this 21st century era, iv) the result of

the study indicated that the ability of TPACK from elementary school teachers can be developed by continuous professional development programs on TPACK and arranging hands-on activities to develop 21st century skills.

- b. TPACK has significant implications for teachers, because every teaching context is unique and there are varied interactions between technology, pedagogy, and content, there is not a universal or "one-size fits all" solution to the problem of teaching. Due to the intertwined relationships among technology, pedagogy and content, teachers face a great number of decisions (Koehler & Mishra, 2005).
- c. TPACK also has implications for teacher educators, dozens of methods have been proposed for the development of TPACK, and they vary in their effectiveness. Among various approaches, an emphasis upon how teachers integrate technology in their practice is more important than the emphasis upon what teachers integrate in their practice (Mishra & Koehler, 2006).
- d. It is indeed an inevitable circumstance to train the teachers and educators to align with the New Education Policy 2020 framework. For the achievement of NEP 2020 technology integration vision, there is a need for technology education to become an integral part of teacher education, moving beyond teaching technology literacy in isolation

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ENHANCING RESILIENCE AND AUTONOMY: EXPLORING THE ROLE OF SELF-DETERMINATION THEORY IN REDUCING SCIENCE ANXIETY AMONG CHEMISTRY PRE-SERVICE TEACHERS

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ABSTRACT

This study investigates the role of Self-Determination Theory (SDT) in reducing chemistry anxiety among preservice teachers by enhancing resilience and autonomy. The research used a mixed-method approach to sample second-year students from two South African universities. Quantitative data were collected using the Betz (1978) anxiety questionnaire, while qualitative data was gathered through semi-structured interviews. The study employed resilience-building strategies such as the Growth Zone and Relaxation Response Model. The statistical results showed that chemistry anxiety is gendered. Results indicated that interventions significantly improved participants' competence, emotional awareness, and cognitive regulation, aligning with SDT's competence, autonomy, and relatedness constructs. The findings suggest that fostering supportive educational environments can mitigate chemistry anxiety and promote intrinsic motivation and professional growth. The study recommends integrating resilience-building workshops into teacher training programs to better prepare pre-service teachers for handling anxiety and stress in their future careers.

Keywords: Self-Determination Theory (SDT), Chemistry Anxiety Reduction, Resilience-Building in Teacher Education

INTRODUCTION

Chemistry anxiety has been widely acknowledged as a barrier to effective learning and teaching among pre-service teachers. This anxiety hampers their academic performance and affects their confidence and enthusiasm in teaching complex scientific concepts. Numerous studies have addressed science anxiety among students (Mallow, 2006; Udo et al., 2004), yet research focusing on pre-service teachers, especially in chemistry, remains limited. While interventions targeting content knowledge improvement are well documented, less attention has been given to psychological frameworks that may reduce anxiety by fostering resilience and autonomy. Previous research on resilience in education has primarily focused on high school students, with relatively few studies examining how resilience-building strategies might be employed in higher education, particularly in teacher preparation programs (Johnson et al., 2016; Day & Gu, 2013).

This study, therefore, seeks to bridge these gaps by examining the role of Self-Determination Theory (SDT) in reducing science anxiety and promoting resilience and autonomy among chemistry preservice teachers. This research aims to deepen understanding of how psychological frameworks can be integrated into teacher education to improve teaching efficacy and emotional well-being.

In this paper, we focus on SDT and Mathematical Resilience (MR) to argue that their relationship and use alleviate STEM anxieties experienced by pre-service teachers in mathematical concepts embedded in chemistry courses. SDT presents three basic universal psychological needs: competence, autonomy and relatedness, which must be met for people's ongoing growth, veracity, and well-being (Deci, 2017; Ryan & Deci, 2024). Competence refers to capability and effectiveness in a task, autonomy denotes volition and self-approval, and relatedness signifies a sense of belonging to a particular societal group (Gagne & Deci, 2005; Deci, 2017).

The process of teaching and learning that satisfies these three needs is critical for motivation, volition, and positive conceptual understanding outcomes, particularly in STEM mathematical concepts.

Therefore, supportive social environments should be upheld in lecture rooms and classrooms to promote students' self-regulation, relatedness and well-being. Hence, this study engages SDT and its elements to support pre-service teachers' resilience against mathematical anxiety in STEM subjects, especially chemistry (Chan et al., 2023).

Johnston-Wilder and Lee (2010) define Mathematical resilience as a constructive approach that enables students to overcome emotional barriers in mathematics, such as anxiety and fear. This article adopts six components postulated by Johnston-Wilder and Lee (2010) and Johnston-Wilder et al. (2016). These include encouraging a growth mindset (mindset); promoting collaborative learning (relatedness); providing students with opportunities to articulate and reflect their understanding (willingness and reflection); understanding the personal and practical value of mathematics (value); creating a supportive community involving teachers and non-specialists (support); recognising the struggle and effort are part of the learning process (struggle).

METHODOLOGY

The study employed a mixed-method approach to evaluate the effectiveness of resilience-building strategies for pre-service teachers. The quantitative data was collected to assess the anxiety levels of participants. The Betz (1978) anxiety questionnaire was administered before the interventions to measure anxiety levels. Qualitative data involving semi-structured interviews was collected to explore participants' perceptions of resilience and autonomy in their professional development. The study purposefully sampled second-year students from two universities: University A = 116 (88 Female; 28 Male) and University B = 97 (38 Female; 59 Male). Each researcher conducted a whole class intervention at his/her university.

The study incorporated the Growth Zone Model (GZM), the Hand Model of the Brain, and the Relaxation Response Model to understand participants' cognitive and emotional regulation during high-pressure teaching situations. These models helped frame the interventions, offering structured ways to promote resilience.

The quantitative data were analysed using descriptive statistics to summarise the anxiety levels. A thematic analysis (Braun & Clarke, 2006) was employed for the qualitative data to analyse the three key constructs of the SDT.

RESULTS AND DISCUSSIONS

A two-way ANOVA univariate SPSS analysis tool was used to investigate the main effect of anxiety levels on the gender of pre-service chemistry students at two different universities. The dependent variable was the anxiety levels of pre-service students, and the two categorical independent variables were the universities and gender.

Descriptive statistics

Descriptive statistics reveal that University B (78.4%) has a higher percentage of students with moderate anxiety than University A (50.4%). However, University A (28.4% & 5.2%) had higher percentage scores in moderately high and very high anxiety than University B (18.6% & 0.0%), respectively. Nonetheless, University A scores as low as 3.1% for students with low anxiety compared to 15.5% of their counterparts at University B. This shows there is a higher percentage of students with anxiety levels at University B than at University A. students. Female students are more likely to experience moderate anxiety compared to their male counterparts, who exhibit a broader range of anxiety levels, including low and very high anxiety. This suggests that gender may play a significant role in the anxiety experiences of university students. To determine the differences portrayed in Figure 1 are important, further analysis of means and statistical differences was computed below.

Statistical analysis

To test the hypothesis, the data for the two universities were subjected to a two-way ANOVA univariant analysis. From the analysis, the descriptive mean score values, the Levene test, and the test between subjects' effects were scrutinised for inferences.



Figure 1: Comparison of mean score values per university and per gender

According to Figure 2, the anxiety mean scores for females are generally higher than for males across the two universities. University A's overall mean score (2.2328) is slightly above university B's (2.1546). Standard deviation values show more inconsistencies in anxiety scores among students at both universities.

Participants' Perceptions of Resilience and Autonomy

The SDT posits that fulfilling three basic psychological needs (competence, autonomy, and relatedness) is fundamental to nurturing motivation and well-being among students. The results of the study align closely with these constructs, providing a framework for understanding how resilience-building strategies can mitigate chemistry anxiety among pre-service teachers.

Gradual Development of Competence

The study's findings indicate that pre-service teachers experienced a gradual development of competence as they engaged with complex chemistry concepts. This aligns with SDT's assertion that competence is cultivated through the experience of overcoming challenges and engaging in optimally difficult tasks. As participants stepped outside their comfort zones and applied the Growth Zone Model (GZM), they reported increased confidence in their abilities to tackle challenging material. This is consistent with the literature, which emphasizes that competence is not merely an inherent trait but a skill that develops through practice and feedback (Stanton et al., 2020). Moreover, the structured guidance provided through resilience-building workshops played a critical role in this process. Research has shown that feedback and support are essential for fostering a sense of competence, as they help individuals navigate obstacles and reinforce their self-efficacy (Amato et al., 2016).

Increased Emotional Awareness and Regulation

The findings also highlighted improvements in emotional awareness and regulation among pre-service teachers, which directly relates to the SDT construct of autonomy. Autonomy refers to the need to feel in control of one's actions and decisions. This finding is supported by research indicating that emotional regulation is crucial for maintaining autonomy, as it allows individuals to make deliberate choices rather than being overwhelmed by external pressures (Skewes et al., 2018). The Relaxation Response Model, which was employed as part of the intervention, contributed to this increased emotional awareness. This aligns with the broader literature on SDT, emphasising that autonomy is enhanced when individuals can effectively regulate their emotions and make choices that align with their values and goals (Howard et al., 2016).

Improved Cognitive Regulation

The study also found that pre-service teachers effectively regulated their thoughts and emotions, engaged deeply in tasks, and persisted in facing challenges. The GZM and the Relaxation Response Model provided the strategies that supported the development of competence and autonomy among the participants. Wijnen et al. (2017) highlighted the importance of incorporating resilience-building strategies into teacher training programs, as they can significantly enhance pre-service teachers' psychological resources

CONCLUSIONS AND RECOMMENDATIONS

In conclusion, the findings provide valuable insights into the interplay between chemistry anxiety, resilience-building strategies, and the constructs of Self-Determination Theory. By focusing on the gradual development of competence, emotional awareness, and cognitive regulation, the interventions effectively addressed the psychological needs of pre-service teachers. This alignment with SDT underlines the importance of fostering supportive educational environments that promote intrinsic motivation and professional growth. Based on these findings, the study recommends that teacher training programs integrate resilience-building workshops into their curricula. These workshops would emphasize cognitive and emotional regulation strategies, preparing pre-service teachers to handle anxiety and stress more effectively in their future teaching careers.

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INTEGRATION OF TECHNOLOGY IN TEACHING PHYSICS: BENEFITS, CHALLENGES, AND SOLUTIONS

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ABSTRACT

The integration of technology in physics education is reshaping traditional teaching methods, providing innovative ways to comprehend complex concepts that are often difficult to grasp through conventional approaches. Generally, for college physics teachers, how to make physics education more challenging, relevant, and attractive for students and how to stimulate the development of creative thinking, problem solving, and other higher cognitive skills are significant challenges. A major challenge is the preparation of teachers to use technology in this direction. This shift toward a tech-enhanced educational model equips students with the skills necessary for a future driven by technology, ensuring that physics instruction stays relevant and effective. Tools like simulations, virtual labs, and interactive software create more engaging and immersive learning environments, allowing students to better visualize and interact with physical phenomena. SEELab3 & ExpEYES17 combine hardware and software to enable students to perform hands-on experiments, automate data collection, and analyse results in real-time. This approach not only modernizes physics education but also fosters a more interactive and accessible learning experience. A hands-on workshop series on "Computer Interfaced Physics Experiments Using ExpEyes17/SeeLab 3" was organized at Shri Shivaji Education, Maharashtra, India. Nearly 44 UG College students from various institutes of Amravati University, Maharashtra, India, participated in this course. They performed various experiments on the SEELab3 & ExpEYES17 hardware kit and observed results on the software interface. Experiments based on electrical, electronics, Python-based, and simple basic experiments were performed by students. Qualitative analysis of pre and post surveys, classroom observation and focus group discussion showed that the integration of technology in teaching physics helps to enhance their imagination and interest in physics.

Keywords: Integration of technology, Physics education, College student, SEELab3, ExpEYES17

INTRODUCTION

The integration of technology in education has significantly transformed teaching methodologies, particularly in physics education, where complex concepts can be abstract and challenging to understand (Faresta et al., 2024). Physics, as a fundamental science, requires deep cognitive engagement and an ability to apply concepts to real-world problems. However, traditional approaches to teaching physics often struggle to engage students in creative thinking, problem-solving, and higher-order cognitive skills (Bigozzi et al., 2018). Governments and educational institutions worldwide have recognized the importance of enhancing science and technology education, leading to initiatives such as STEM (Science, Technology, Engineering, and Mathematics), STEAM (which incorporates Arts), MINT (Mathematics, Informatics, Natural Sciences, and Technology in Germany), and IBSE (Inquiry-Based Science Education). These approaches aim to make science education more relevant, practical, and attractive to students. Technology can play a critical role in achieving these goals, enabling students to engage in inquiry-based learning, conduct simulations, and perform investigations that were previously inaccessible due to resource limitations (Yang et al., 2023).

Opportunities and Challenges

Despite the clear advantages of technology in enhancing physics education, its application remains limited in many educational settings (Haleem et al., 2022). A significant barrier is the inadequate preparation of teachers to effectively integrate technology into their lessons. To address this, an innovative teacher development course was designed to prepare both pre-service and in-service

teachers for the use of ICT (Information and Communication Technology) in physics education, specifically focusing on its application in IBSE lessons. This proposal outlines the design and implementation of this course across various educational and cultural contexts, its pedagogical foundations, and the resulting learning outcomes for participating teachers.

METHODOLOGY

In this qualitative research, 44 UG undergraduate students participated in this course. A hands-on workshop series titled "Use of Integrated Technology in Physics Education: Computer Interfaced Physics Experiments Using ExpEyes17/SeeLab 3" was held at Shri Shivaji Science College, Maharashtra, India. It emphasized the relevance of this workshop in the context of the updated syllabus introduced and in alignment with the New Education Policy (NEP) 2020. The workshop aimed to modernize physics education by showcasing how technology, such as simulations, virtual labs, and interactive software, can be integrated into traditional teaching methods to enhance learning. One of the key highlights of this course was the demonstration of SEELab3 & ExpEYES17, a tool that combines hardware and software, enabling students to perform hands-on experiments, automate data collection, and analyse results in real-time. SeeLab 3.0 is the upgrade to ExpEYES17. It works on the shared ExpEYES17 software and app. There is an emphasis on the importance of integrating modern technology into physics experiments to enhance students' learning experiences.

The course event saw participation from 44 undergraduate students representing various institutions. These students were introduced to cutting-edge tools that allowed them to visualize and interact with physical phenomena in ways that are not possible through conventional means. This tech-enhanced approach provided a more immersive and engaging learning environment, making complex concepts easier to understand and helping students develop skills that are crucial for a technology-driven future (Ainsworth, 2006). The workshop course was an excellent opportunity for students to experience firsthand how integrating technology into physics education not only makes the subject more accessible but also encourages a deeper interaction with the material.

MATERIALS AND PROCESS

Course Design and Pedagogical Approaches

The course aimed to equip teachers with both the technical skills to use ICT tools and a deep understanding of the pedagogical benefits of integrating technology into physics education (PhET Interactive Simulations, 2023). The course structure was based on two main principles:

Depth-First Learning

This principle emphasizes focusing on a smaller number of topics in greater detail rather than covering a broad range of topics superficially. By delving deeply into specific ICT tools and techniques, teachers can develop a strong conceptual foundation for using technology in physics education.

Theory-Practice Cycle

The course was structured around iterative cycles of theory and practice. Each cycle introduced a theoretical concept followed by practical exercises where teachers applied these concepts using specific demonstrations of Lab-3 ExpEYES, a tool that combines hardware and software, enabling students to perform hands-on experiments, automate data collection, and analyse results in real-time.

Implementation in Different Contexts

The course was implemented in different colleges of Maharashtra, India. The students from various institutes along with their teachers from Amravati University participated in it and represented distinct educational cultures and levels of technological advancement.

RESEARCH METHODOLOGY

Participants

Nearly 44 undergraduate students along with their teachers representing various institutions, allowing for a diverse range of experiences and expectations. The teachers focused on building a strong foundation for future teaching and they were encouraged to integrate new skills into their existing teaching practices.

Data Collection

To evaluate the effectiveness of the course, data were collected through multiple methods:

Pre- and post-course surveys were conducted to assess changes in participants' confidence and motivation regarding the use of ICT in physics education.

Classroom observations were conducted to evaluate the application of new skills and technologies in real teaching environments.

Focus group discussions with participants were held to gather qualitative data on their experiences, challenges, and perceptions of the course's relevance.

RESULTS AND DISCUSSIONS

Results

The course was well received by participants across various institutes, with notable improvements in their confidence and competence in using ICT for physics education. Key results included:

Increased Teacher Confidence

Participants reported significant growth in their ability to use technology in their lessons, moving from basic skills (e.g., using SEELAB-3) to more advanced techniques such as simulations, interactive whiteboards, and online labs. The iterative theory-practice model was particularly effective in reinforcing these skills.

Positive Impact on Student Engagement

Teachers noted a marked increase in student engagement when using technology-enhanced lessons. Simulations and interactive tools were particularly effective in making abstract physics concepts more concrete and relatable to students' real-life experiences.

Cultural Adaptation

The course's flexible design allowed for successful adaptation across different educational contexts.

Sustained Motivation

Many participants expressed a desire to continue integrating technology into their teaching practices after the course, highlighting the course's effectiveness in fostering not just technical skills but also a lasting appreciation for the value of integrated technology in physics education.

Discussion

The success of the course demonstrates that well-designed professional development can effectively prepare teachers to integrate technology into physics education (Osborne and Dillon, 2010). The depth-first and theory-practice cycle approaches proved critical in ensuring that participants not only learned how to use See-lab 3 Exp-EYES for performing experiments but also understood their pedagogical value. Additionally, the course's flexible design allowed it to be adapted to various cultural and educational contexts, demonstrating its potential for broader application.

However, several challenges remain. First, access to technology is still a significant issue. While lowcost solutions can mitigate this to some extent, continued investment in educational technology infrastructure is necessary. Second, ongoing support for teachers after completing such courses is essential to ensure sustained use of ICT or new techniques in the classroom. Finally, further research is needed to explore the long-term impact of technology integration on student learning outcomes.

CONCLUSIONS

This proposal has presented the design, implementation, and evaluation of a course aimed at preparing teachers to use integrated technology in physics education. The course's success in enhancing teacher skills and motivation, along with its adaptability across different contexts, highlights its potential as a model for future teacher development initiatives (Joolingen, De Jong & Dimitrakopoulou, 2007). By empowering teachers to use technology effectively, we can make physics education more challenging, relevant, and attractive for students, ultimately fostering the development of critical thinking and problem-solving skills essential for success in the modern world.

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PROMPT ENGINEERING WITH ChatGPT A PARADIGM SHIFT IN EDUCATION : A GUIDE FOR SCHOOL TEACHERS

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ABSTRACT

Advancements in the area of Artificial Intelligence (AI) significantly impacted education in the era of the fourth industrial revolution. ChatGPT is an AI-powered application designed to generate chat responses in a conversational style, paving the way for flexible and responsive education to become mainstream. Various research on ChatGPT has sparked debates about its potential implications to support education for providing adaptive and personalised environments. This ongoing descriptive study analysed the use of ChatGPT by 24 schoolteachers who participated in a course in the first step of study. It aimed to evaluate teachers' initial knowledge regarding ChatGPT, particularly its educational applications and potential advantages, before their course. Based on connectivism learning theory the present study sought to pinpoint effective prompts that teachers could incorporate into their teaching methods. Furthermore, it aimed to gauge the impact of the course on enhancing teachers' awareness and understanding about ChatGPT, basically prompt engineering with its possible applications. The data was collected from base survey, feedback form, discussion forum and assignments and analysed using the descriptive method. The first step of the study revealed that teachers have minimal baseline knowledge of ChatGPT but after the course they found ChatGPT as their virtual teacher assistant. It emphasises the importance of preparing teachers for a paradigm shift in education. The study found a direct correlation between cognitive engagement and interaction levels of connectivism theory. However, as interaction levels increase, participant involvement tends to decline.

Keywords : ChatGPT, Connectivism theory, Prompt engineering, School Teachers, Paradigm shift in education

INTRODUCTION

Effective classroom management is essential for creating a conducive learning environment, where a teacher uses a blend of strategies to create an ideal learning environment. Engaging lesson plans, suitable teaching methodologies, appropriate teaching aids, and diverse assessment strategies compose a toolbox that collectively foster an optimal learning atmosphere. Whereas the learning outcomes of the class depends upon the satisfactory completion of learning needs of the student. Nevertheless, personalised lesson plans in a heterogeneous classroom is a quiet challenge.

Prompt Engineering as an important emerging skill

Prompt engineering is the process of designing, refining, and optimising input prompts to effectively communicate the user's intent to a language model like ChatGPT. It can be called as the art of crafting effective prompts which can guide ChatGPT to generate desired responses (Ekin, 2023). It also plays a significant role in enhancing the user experience and ensuring effective communication when interacting with AI models like ChatGPT (Ray, 2023). According to Ekin (2023), the quality of the prompts directly affects the quality of the generated responses, understanding the nuances of prompt engineering is vital for creating effective and meaningful interactions with ChatGPT.

ChatGPT 3.5 has the potential to revolutionise education systems providing personalised learning experiences (Dempere et al., 2023). Teachers can incorporate ChatGPT by leveraging the AI's capabilities to help create, organise, and structure course content in a coherent and effective manner (Dilmegani, 2024). Nevertheless, ChatGPT will not replace teachers (Atlas, 2023), instead teachers

can use it to enhance their practice (Lo, 2023). However, Dilmegani (2024) revealed educators' concerns about chatbots amplifying plagiarism while recognizing their transformative potential in education, emphasising the importance of ethical guidelines and proactive integration into teaching approaches. Winkler & Söllner (2018) emphasised the need to explore the potential of Chatbots for mentoring students. Teachers should adapt to this upcoming AI technologies like ChatGPT to keep education relevant and effective. They should learn how it works, how to access information, and create engaging and interactive lessons. They should have expertise in prompt engineering (Ding et al., 2023 & Farrokhnia, et al., 2023). Due to the naiveness in using ChatGPT, Barrett & Pack (2023) stressed the essentialness of teacher training. Hence, in this study the first step of our course in September 2023 for the schoolteachers on the skill of prompting questions was conducted. As the usage of the tool is at infancy, the teachers were provided with a variety of prompts to assist in effectively utilising ChatGPT.

ChatGPT: OPPORTUNITIES AND CHALLENGES IN EDUCATION

ChatGPT presents numerous opportunities in education. It enables personalised learning, 24/7 virtual guidance, and grants access to material. It provides a simulated experience of having assistance from a more knowledgeable person. It gives a wide range of potential applications including assistance in writing, serving as research assistant, offering individualised feedback, developing writing and communication skills, creating lesson plans, making presentations, grading student work, designing syllabus, quizzes, and evaluating student progress (Atlas, 2023). Furthermore, ChatGPT facilitates adaptive learning, and aids in developing innovative assessments (Koos & Wachsmann, 2023).

Along with opportunities ChatGPT poses several challenges, and potential issues and concerns (Panagopoulou et al., 2023) like generation of incorrect information, undermining students' critical thinking skills (Woodland, 2023) and lack of emotional intelligence. It gives inaccurate, fabricated, or biased information (Mohammad et al., 2023) also there is a risk of plagiarism, loss of critical thinking skills, and difficulty in evaluating information generated by ChatGPT (Rahman & Watanobe, 2023). Currie & Barry (2023) highlighted concern for cheating on exams and assignments. Hence, the use of ChatGPT requires careful consideration of ethical principles to ensure its responsible and ethical integration in various domains (Ali & Djalilian, 2023).

Rationale of the study

While numerous studies have explored the application and significance of ChatGPT in medical science (Lee, 2023), its utilisation in teacher and school education has not been extensively explored, leaving a gap in harnessing its potential. Well-crafted prompts enable teachers to craft input instructions to guide ChatGPT to generate educational content. Considering this, it's crucial for teachers to know how to formulate prompts that align with their teaching objectives. Following this rationale the objective of this ongoing study is to assess the impact of a ChatGPT course on teachers' knowledge, highlighting the need for teachers to not only be proficient in ChatGPT usage but also skilled in formulating prompts. Along these lines, the present research was examined the following research questions:

RQ 1: - What is the baseline level of knowledge that schoolteachers currently possess regarding ChatGPT, particularly its applications and potential benefits in education, before receiving training?

RQ 2: - What are the various prompts that schoolteachers can effectively utilise in their instructional practices?

RQ 3: - To what extent has the course improved schoolteachers' awareness and knowledge about ChatGPT and its potential applications in the field of education?

To answer the above research questions we conducted a course on ChatGPT in online asynchronous mode using Google Classroom.

THEORETICAL FRAMEWORK

Theory of connectivism

George Siemens and Stephen Downes developed a theory for the digital age, called connectivism (Duke, et al., 2013). This theory provides a framework for understanding the role of humans and appliances in the learning process and how they interact with each other to create new knowledge (Omodan, 2023). Siemens (2005) suggested implication of the connectivism theory as designing learning environments which facilitates learning by incorporating internet technologies into the educational process.

ChatGPT views learning as a networked phenomenon influenced by technology and socialisation, where learners develop mental connections between pieces of information through interaction with various sources (Liet al. 2022).

Voskoglou (2022) described Connectivism as a new theory for understanding learning in our digital era. According to Kop (2011) ICTs has led to the concept of connectivism, emphasising learning through networks and digital resources. Connectivism serves as both a learning and instructional theory in the 21st century (Kropf, 2013). It provides a conceptual framework for understanding how learning occurs in a digital environment (Dziubaniuk et al. 2023). The theory explains how internet technologies help people learn and it creates new learning opportunities by using the latest digital technologies e.g. twitter, wikis, blogs, open educational resources etc.

RESEARCH METHODOLOGY

The below section discusses the research methodology used in the study.

Method

Considering the nature of the present study we employed a descriptive method. Data was collected using a survey. As described by Mathiyazhagan & Nandan (2010) survey research is a descriptive research method used for the collection of data from the representative sample of the target population.

Participants and Data Collection

A purposive sampling technique was employed to select 24 participants (see Table-1) out of the 56 practising teachers who had enrolled in the Google Classroom. These 24 individuals successfully completed the baseline test and the feedback form. A purposive sampling which can be used for both qualitative and quantitative research (Tongco, 2007) was used as a sampling technique. The study collected data using base survey, feedback form, discussion forum and assignments which validated from five experts.

Data before the training program was gathered through a Google Form that included 17 closed-ended questions (see Table 1), and one open-ended question. Post course teachers' feedback and knowledge assessment was collected using a gamification tool Quizizz.com. It included 14 closed-ended questions.

Planning and Implementation

The section below discusses in detail about the planning of the course and Implementation guided by Connectivist Levels of Interaction.

Planning

A Google Classroom was created for the purpose of uploading learning material, assignments, base survey questionnaires, and feedback form. Discussion forums were used for sharing the ideas among the participants. Within this platform, a course was designed and for its implementation four sessions were planned. In each session a presentation was shared on Google Classroom. Course design is shown in Appendix-1.

The first Session was focused on the objective of the course, information related assignment submission and the outline of the session and as they were novice to ChatGPT this session also familiarised them with it. The objective of the next session was to give understanding about prompt engineering. The following two sessions were planned to help them to know how prompts should be designed.

A WhatsApp group was formed to facilitate communication and to provide a platform for easy interaction and resolving doubts. Participants were guided to join the Google Classroom and log in to ChatGPT. At the outset, an initial base survey was administered, and upon conclusion, participants were provided with a feedback form.

Implementation Guided by Connected Levels of Interaction

To facilitate effective and meaningful learning experiences we used the conceptual framework from connectivism theory having four levels of interaction as- i) operation interaction, ii) wayfinding interaction, iii) sensemaking interaction, and iv) innovation interaction designed by Wang, et al. (2014). This framework is inspired by the hierarchical model for instructional interaction (HMII) proposed by Chen (2004) in distance learning. Connectivism theory was also used in the study on ChatGPT in Advanced Programming Courses by Gottipat et al. (2023).

The following Figure-1 shows the interconnectedness between four interaction levels and increase in cognitive engagement and learner's interaction (Wang, et al., 2014).



Figure 1: The four interaction levels, cognitive engagement and learner's interaction (Wang, et al., 2014)

The following paragraph gives the details about four interaction levels as suggested by Wang, et al. (2014) and the incorporation of it in our course.

- 1. Operation interaction is the first level that provides the possibility to connect with different groups of people and information, and to change their sensemaking behaviours.
- 2. Way finding interaction is the second level in which learners actively connect with technologies and people in groups having similar learning goals, to share and exchange knowledge.
- 3. Sensemaking interaction is the third level of connectivism framework. It emphasises learnerlearner, learner-teacher and learner-content interaction. It is a collaborative process that includes information sharing, discussion, negotiation, reflection, and decision-making. In this level the learner shows more interaction as compared to previous interaction level.
- 4. Innovation interaction is the deepest, highest and most challenging form of interaction in which the learner is involved in artefact creation. The learner creates something new or a modified version. This level requires the deepest cognitive engagement compared to all four interactions. To reach the highest level, the learner should have deepest cognitive engagement, self-directedness, and creativity.

Based on four interaction levels as suggested by Wang, et al. (2014) the researchers designed a Framework for Interaction and Cognitive Engagement in Connectivist Learning (see Figure-1).

Course Design and Implementation

During the implementation of the present study initially a WhatsApp group was formed to give the instructions, guidance and for solving the doubts of the participants. They were asked to join the Google classroom using the shared link. Novice participants were guided to using Google Classroom.

The paragraph below discusses the course design of four sessions and its implementation in detail.

Session - 1

During the session, the participants were guided to install ChatGPT. Links for installing ChatGPT on mobile and laptop were provided (<u>https://chat.openai.com</u>). The session incorporated knowledge about how ChatGPT generates data, benefits and challenges of using it. Also introduced the use of ChatGPT for various interactive activities like generating questions answers, lesson plan, rubrics, blueprint, planning of virtual tours, generating debate topics, creative writing etc. The Session-1 concluded by creating a discussion forum where participants were encouraged to share their perspectives on the advantages of utilising ChatGPT.

Session - 2

Operation interaction along with Wayfinding interaction was continued as emphasis was given on building social networks and informational networks. During session -2, the participants were given an understanding about prompt engineering and its importance as it is essential for controlling the model's behaviour and generating accurate and useful responses. Initially, they were introduced with various features and buttons of ChatGPT like +New Chat, Regenerating button etc. They were given clear understanding about providing a source material and a clear, context-rich prompt for obtaining accurate and relevant results. Next, they were given steps for giving the prompts to ChatGPT as - 1) Select and highlight the shared prompt; 2) Copy the prompt; 3) Go to the ChatGPT platform; 4) Click in the chat box where you will talk to GPT, and 5) Paste the prompt and press enter. At the end of session - 2 the first assignment was shared.

In the first assignment participants were given a paragraph and asked to paste it into ChatGPT's workspace. Subsequently, they were directed to use the given prompt to create a lesson plan based on the STEAM approach and submit their response. A discussion was also initiated about the variations in outcomes when using the same prompts. Getting different responses for the same prompt shows sensemaking interaction. On discussion forums we noticed learner-learner, learner-content and learner-teacher interaction in a deeper sense.

Session - 3

As this session provided participants with subject specific prompts (Appendix-1), group interaction among particular subject teachers was observed.

Session - 4

This session provided prompts on creative aspects, designing rubrics, method of teaching etc. At the end of session -4 second assignment was shared. However, following the session, only a few of the participants shared their creative prompts.

In the second assignment focusing on innovative applications of ChatGPT in teaching, the emphasis was on fostering innovative interactions. Among the 24 participants only four participated in this aspect of the assignment. Among them, a science teacher devised an assignment involving ChatGPT, where students were instructed to bring a short paragraph using Chat GPT on deforestation using a provided prompt. The plan was for students to generate responses from ChatGPT, which they would subsequently share in class. This would lead to a discussion on environmental conservation. Similarly,

a mathematics teacher crafted a prompt for her students aimed at generating a variety of mathematical problems based on concept in proportion.

In the present study researchers observed that initial stages, wayfinding and sensemaking showed participants' involvement, while fewer participants reached the innovation level. This pattern of teacher participation aligns with findings from Wang et al. (2014) study, which states that as the interaction levels become more innovative, the number of participants tends to decrease.

DATA ANALYSIS AND DISCUSSION

Our research primarily focuses on empowering teachers with the knowledge about the ChatGPT and guiding them for its practical use in their instructional process. Though 56 participants joined the Google Classroom only 24 participants filled the base survey and feedback form. Also, among them a few took part in a discussion forum and submitted the assignment. Here, one of the reasons can be their limited competency in basic digital literacy and learning literacy as these are essential to engage in connectivist learning (Wang, et al. 2014).

During the program implementation before and after the course participants' responses were collected and analysed. The section below discusses the responses collected on closed and open-ended questions in base surveys, participants' feedback and Submission of Assignment based on levels of Connectivist learning.

The following paragraphs analyses and discusses the data of the base survey, feedback form, discussion forum and assignments.

Data Analysis and Discussion of Base Survey

Below is the data analysis and discussion of the Base survey. It is divided into two parts - Data analysis and discussion of closed ended questions of base survey and Data analysis and discussion of open-ended questions of base survey.

Data Analysis of Closed-Ended Questions of Base Survey

The base survey included 17 closed-ended questions (see Table-1, Table-2, Table- 3), and the following sections provide an analysis of these questions.

The analysis of teacher backgrounds indicates a diverse distribution of subjects they specialise in. Approximately 37.5% were focused on mathematics and science, closely followed by 33.8% specialising in language arts. Moreover, 20.8% of participants were involved in teaching social studies, while 4.2% were responsible for art and music instruction. A quarter of the participants, precisely 25%, were engaged in teaching other subjects, reflecting the varied expertise within the educator group.

The participants from various grade levels and teaching various subjects were enrolled for the course. Regarding technology integration in classroom practices, 50% of participants reported moderate familiarity. And 45.8% expressed interest in using AI-driven tools or chatbots but reported they haven't used them; rather 54.2% of participants expressed willingness for integrating ChatGPT-generated content into their lesson plans (see Table-1).

#	Question	Responses (N=24)	%
1. Teaching subjects	Which subject(s) do you primarily teach? (You can choose multiple options)	Science	37.5%
		Mathematics	37.5%
		Language Arts	33.3%
		Social Studies	20.8%
		Arts and Music	4.2%
		Physical Education	0%
		Other	25%
2. Grade	For which grade level(s) do you primarily teach? (You can choose multiple options)	Elementary (Pre-K to Grade 5)	37.5%
		Middle School (Grade 6 to 8)	45.8%
		High School (Grade 9 to 12)	33.3%
		College/University	29.2%
3. Familiarity with	How familiar are you with integrating technology into your teaching practices?	Very familiar	20.8%
technology		Somewhat familiar	50%
4.		Neutral	16.7%
		Not very familiar	12.5%
		Not familiar at all	0%
	Have you previously used AI- driven tools or chatbots in your teaching?	Yes, frequently	0%

Table 1. Geographical distribution, experiences & future perspectives of using Technology and AI tools

		Yes, occasionally	29.2%
		No, but I'm interested	45.8%
		No, never	25%
5. Future Perspectives	How likely are you to incorporate ChatGPT- generated content in your lesson plans?	Very likely	12.5%
		Likely	54.2%
		Neutral	25%
		Unlikely	8.3%

Prior understanding for application of ChatGPT among participants shows: 75% recognized it as a language model for interactive lessons and student queries, 79.2% recognized ChatGPT as an AI-based text generation tool. 66.7% correctly understood ChatGPT's support for critical thinking and providing additional resources, 75% know that it can be used to assist in lesson planning and content generation. The study found misunderstandings of participants that ChatGPT couldn't provide personalised learning (29.2%), enhance creativity (41.7%), minimise teacher workload (41.7%), or improve accessibility for diverse learners (29.2%). But on the other hand, 79.2% of participants correctly identified its versatility across subjects like science and literature and another 79.2% of participants correctly identified it for natural language understanding but some of them also misunderstood its use for stock trading, video game development and weather forecasting (see Table-2).

#	Question	Responses (N=24)	%
1.	What is Chat GPT, and how can it be applied in an educational context?	ChatGPT is a gaming platform for students. It can be used for creating educational games.	20.8%
	(You can choose multiple options)	ChatGPT is a language model AI. It can generate interactive lesson plans and answer student questions.	75%
		ChatGPT is a video conferencing tool for online classes.	8.3%
2.	Which of the following best describes ChatGPT's function?	A video conferencing tool	8.3%
	(choose as many options)	A language translation service	16.7%
		An AI-based text generation tool	79.2%
		A social media platform	12.5%

Table 2. Teachers Prior understanding about application of ChatGPT

		I don't know	4.2%
3.	How can ChatGPT be used to enhance classroom	By replacing all teacher-student interactions	25%
	engagement? (choose as many options)	By automating all aspects of teaching	25%
		By fostering critical thinking and providing additional resources	66.7%
		By eliminating the need for teacher involvement	12.5%
		I don't know	8.3%
4.	In education, how can Chat GPT be utilised? (choose as	As a substitute for teachers	20.8%
	many options)	To automate grading without review	4.2%
		To assist in lesson planning and content generation	75%
		I don't know	8.3%
5.	Which of the following is/are NOT potential benefits of using	Personalised learning experiences	29.2%
	ChatGPT in education? (choose as many options)	Enhanced creativity in students	41.7%
		Increased teacher workload	41.7%
		Improved accessibility for diverse learners	29.2%
		I don't know	12.5%
6.	ChatGPT can assist in	Only mathematics	0%
	the following subjects?	Only history	4.2%
	(choose as many options)	A wide range of subjects, from science to literature	79.2%
		None, it is limited to language translation	8.3%
		I don't know	8.3%
7.	ChatGPT is designed for which	Stock trading	12.5%
	choose as many options)	Video game development	16.7%
		Natural language understanding	79.2%
		Weather forecasting	12.5%
		I don't know	12.5%

While taking prior knowledge 50% of participants correctly identified ChatGPT as "Generative Pretrained Transformer. 66.7% of participants knew ChatGPT's limitation in providing incorrect or biased information. Though 66.7% of participants understood ChatGPT generates text from statistical patterns, 33.3% think it accesses real-time internet data. Additionally, 20.8% misunderstood it as generating text randomly. Whereas the majority of participants (58.3%) correctly identified the internet text dataset as ChatGPT's primary training source. Also, 20.8% indicated they didn't know its training method. 41.7% of participants correctly recognized GPTZero's ability to distinguish between human and AI-written content however, 33.3% misunderstood its capability for complex calculations, and 25% were uncertain about its features (see Table-3).

#	Question	Responses (N=24)	%
1.	What is/are the main limitation/s of ChatGPT when it	General Predictive Transformer	8.3%
	comes to generating text? (choose as many options)	Generative Pre-trained Transformer	50%
		Global Prediction Toolkit	16.7%
		General Purpose Text	0%
		I don't know	25%
2.	What is/are the main limitation/s of ChatGPT when it	It generates text that is too short.	20.8%
	comes to generating text? (choose as many options)	It cannot generate coherent text.	8.3%
		It may sometimes produce incorrect or biased information.	66.7%
		It is too slow in generating responses.	4.2%
		I don't know	12.5%
3.	ChatGPT uses patterns and information from a large dataset	It generates text randomly without any patterns.	20.8%
	to generate text. Which of the following statements are true? (choose as many options)	It relies on personal experiences and emotions.	4.2%
		It generates text based on statistical patterns in the training data.	66.7%
		It accesses real-time information from the internet.	33.3%
		I don't know	4.2%
4.	What is/are the primary	Real-time user conversations	37.5%
	source/s of training data for ChatGPT? (choose as many	A massive dataset of internet text	58.3%
	options)	Encyclopaedias and textbooks	20.8%
		Private research documents	12.5%
		I don't know	20.8%
5.	What is/are the primary	It generates highly creative and imaginative content.	37.5%

Table 3. Teachers Prior Knowledge about ChatGPT

distinguishing feature of GPT Zero ² (choose as many options)	It has the ability to perform complex calculations.	33.3%
Zero: (choose as many options)	It accurately distinguishes between human and AI-written content.	41.7%
	It can predict future events with high accuracy.	8.3%
	I don't know	25%

Discussion on Closed-Ended Questions of Base Survey

Before the commencement of the course responses on base surveys were collected using Google form and were analysed. The responses revealed various misconceptions about ChatGPT among the participants prior to the course. Notably about 50% of participants showed a moderate understanding of the subject. Some participants displayed no prior knowledge of ChatGPT, while others had misperceptions considering it as a gaming tool, a video conferencing platform, or even a social media tool. They showed their misconceptions about its applications ranging from associating it with weather forecasting to stock trading. Only a few recognized the potential of ChatGPT in enhancing classroom engagement, personalising learning experiences, nurturing student creativity, and improving accessibility for diverse learners. Even some participants have a notion that ChatGPT could replace teachers. Participants also showed misconceptions regarding the subject-specific utility of ChatGPT, with some participants in a delusion that use of ChatGPT is limited to English classes. They assume limitations of ChatGPT as it generates incoherent and brief responses and the speed of providing responses is slow.

In addition, there were misconceptions about the operation of ChatGPT including the belief that it generates text randomly without any patterns or that it accesses real-time internet information. Their misconceptions about the sources of ChatGPT's training data included real-time user conversations, encyclopaedias, textbooks, and private research documents. Lastly, they showed their misunderstanding about GPTZero as it can generate highly creative and imaginative content, perform complex calculations, or even predict future events with remarkable accuracy. These different views and misconceptions emphasise the importance of providing the course regarding what ChatGPT can and cannot do within an educational setting. A noteworthy observation was that a significant number of participants expressed a keen interest in incorporating ChatGPT generated content into their teaching practices.

Data Analysis and Discussion of Open-Ended Questions of Base Survey

Including the closed ended questions the base survey also asked one open ended question to get deeper understanding about the participants' vision regarding ChatGPT in impacting the future of education. The following paragraph analyses and discusses the open-ended responses provided by participants in response to "How do you foresee AI-powered tools such as ChatGPT influencing the future of education?"

Data Analysis of Open-Ended Questions of Base Survey

75% participants expressed positive views on the impact of AI tools, mentioning benefits like making teaching more interesting and easier, enhancing the teaching-learning process, and assisting with various aspects of education. 16.66% participants were unsure about or had no specific idea regarding

the impact. Very few (8.33%) participants explicitly stated their intention to use ChatGPT for teaching (Ding et al., 2023). Overall, a majority of the participants (75%) held positive views about the potential impact of AI tools in education, while the remaining participants had either uncertain or no opinions.

Discussion on Open-Ended Questions of Base Survey

Many participants recognized the potential benefits of integrating AI tools into the educational context. They foresee ChatGPT as a virtual assistant that can help teachers to invest their extra time on creative and complex activities. They shared that it can enhance the teaching learning process by incorporating various techniques and strategies as per the classroom's needs, making learning engaging and effective. Two of them recognized the benefit of using it for students as it will provide students with quick access to information. It can assist students in understanding topics, providing detailed explanations, and preparing projects and assignments. However, one of the participants shared that though AI-powered chatbots can assist in the learning process, it will never replace human teachers, as machines can never provide emotional support to students.

A few participants shared challenges and concerns of using AI-powered tools like ChatGPT. They find the need to focus on potential consequences of using such tools. Secondly, one of the participants showed concern about their impact on students' exploration ability and connection with books.

Many participants find ChatGPT as a new technology to learn, they do not have any idea about it, some of them inquired about - How can teachers use ChatGPT for enhancing teaching learning experience? And how to accurately provide a prompt to have suitable output from GPT. This emphasises the need for the implemented course.

Data Analysis and Discussion on Feedback Form

The feedback form comprised 13 questions aimed at assessing the knowledge acquired by the participants concerning ChatGPT after completing the course. The subsequent paragraph delves into an analysis and discussion of the data collected from these feedback forms.

Data Analysis of Feedback Form

Following the course, a substantial 88% of participants now hold the belief that ChatGPT cannot serve as a replacement for human educators. 91.67% of participants are now aware that ChatGPT primarily comprehends and interacts with spoken language. And 87.5% correctly identified ChatGPT's primary training purpose as generating human-like text responses. After attaining the course 62.5% of participants understood that ChatGPT is a natural language processing tool and they correctly understood that ChatGPT generates responses from its training data patterns. Now 75% of participants correctly identified that a prompt refers to an input or instruction given to ChatGPT. However, 17% mistakenly believe it means a user's response to ChatGPT's question. 83% of participants are now aware that ChatGPT can understand and respond to prompts in various languages. 83.33% know OpenAI created the ChatGPT model. 87.5% correctly recognize that ChatGPT can facilitate personalised learning, assist students with disabilities, and provide instant feedback. Now 83.33% of participants believe that educators can ensure the quality of ChatGPT-generated content through careful review. 79.17% understood the importance of prompt engineering as they think providing context and specifying desired outputs increases the effectiveness of prompt; also 75% of participants

recognize that overly complex prompts can be a common challenge. 75% find ChatGPT capable of generating random and unique prompts for creative exercises (see Table-4).

#	Question	Responses (N=24)	%
1.	Can ChatGPT replace	Yes	8.33%
	entirely?	No	87.5%
		Unattempt	4.17%
2.	What type of input	Spoken language	8.33%
	and respond to?	Text-based input	91.67%
3.	What is ChatGPT?	A natural language processing tool	62.5%
		A speech recognition software	37.5%
4.	What is a prompt in the context of	An input or instruction given to ChatGPT	75%
	ChatGPT?	A user's response to ChatGPT's question	17%
		ChatGPT's response	8.33%
5.	Can ChatGPT understand and	No, it only understands English	16.66%
	respond to prompts in different languages?	Yes, it can work with multiple languages	83.33%
6.	How does ChatGPT generate responses?	By using a set of predefined responses	8.33%
		By generating new responses based on patterns in its training data	63%
		By searching a database of previously seen responses	21%
		By randomly selecting words and phrases from a large vocabulary	8.33%
7.	Which company	Microsoft	4.17%
		Google	8.33%
		Amazon	4.17%
		OpenAI	81.33%
8.	What is the potential impact of ChatGPT	It can facilitate personalized learning	4.33%
	on education?	It can help students with disabilities or special needs	8.33%
		All of the above	87.5%
9.	What is the primary purpose of ChatGPT's	To generate human-like text responses	87.5%
	training?	To translate between different languages	4.33%

 Table 4. Effectiveness of implementation program

		To perform complex mathematical calculations	8.33%
10.	How can educators ensure the quality of content generated by ChatGPT for educational purposes?	By not reviewing the content at all	83.33%
		By trusting it completely	17%
11.	When using ChatGPT for teaching, what can educators do to ensure effective prompts?	Provide context and specify the desired output	79.17%
		Never use prompts, only free-form conversation	12.5%
		Use complex jargon and terminology	8.33%
12.	Can ChatGPT generate random prompts for creative exercises?	No, it can only generate responses to prompts	12.5%
		No, it can only generate responses based on its training data	8.33%
		Yes, it can generate random and unique prompts for creative exercises	75%
		No, it only follows a fixed pattern	4.33%
13.	Which of the following is a common challenge when using ChatGPT for prompts in teaching?	Overly complex prompts	75%
		ChatGPT can't generate human-like text	8.33%
		ChatGPT can't understand human language	4.33%
		ChatGPT can't be used for teaching	8.33%

Discussion on Feedback Form

The feedback after the completion of the course unveils valuable insights into the knowledge enhancement among participants about ChatGPT. The responses show that the course made a positive impact on their understanding of ChatGPT. When students have positive attitudes toward online courses, they are more likely to be satisfied with them (Alshammari et al., 2023). A significant proportion of participants now acknowledge that ChatGPT cannot replace human teachers. This indicates that participants have a more realistic understanding of the capabilities and limitations of ChatGPT.

In terms of ChatGPT's functionality it's apparent that the course has effectively communicated ChatGPT primarily understands and responds to spoken language. Also, ChatGPT is a natural language processing tool distinguishing it from the misconception that it's a speech recognition software. Participants have recognized the meaning of what a "prompt" means in the context of ChatGPT. In terms of multilingual capabilities, a substantial portion of participants now understand that ChatGPT can respond to prompts in different languages, dispelling the misconception that it's limited to English only. There found no significant shift in participants' comprehension about How does ChatGPT generate responses? They may have found it challenging to fully comprehend the meaning of "patterns in its training data". For further clarification qualitative insights from the teachers' will be required.

The majority of participants now correctly attribute the development of ChatGPT to OpenAI. They now showcase their awareness for recognizing the ChatGPT's potential for personalised learning, support for students with disabilities, instant feedback and assistance. Participants now have the clear
understanding that generating human-like text responses is the primary purpose of ChatGPT's training. After getting the experience of using prompts, participants acknowledge the importance of carefully reviewing and verifying the content. Overall, the feedback shows the knowledge improvement in participants about the ChatGPT.

Data Analysis and Discussion on Participants Interaction on Google Discussion Forum

The following paragraph analyses and discusses the interaction of participants on Google Discussion Forum.

Data Analysis of Participants Interaction on Google Discussion Forum

Though all the participants joined the discussion forum a limited number of participants (16.66%) were active. All participants found ChatGPT as their virtual personal assistant. A few (16.66%) showed their concern about ethical use of ChatGPT in teaching. Most of the participants (75%) agreed that students' assignments should be designed in a creative way and students should also get the opportunity to use AI tools like ChatGPT which will serve to enhance 21st century skills. Very few participants (12.5%) discussed the variations in outcomes when using the same prompts.

Discussion on Participants' Interaction on Google Discussion Forum

Discussion Forum shows very few participants reached sensemaking interaction level. Participants shared their experiences about novices in using ChatGPT. They shared their thoughts on the essentialness of using technology like AI in an ethical way. As there is a strong possibility of getting the assignment done from ChatGPT they unanimously come to the point that participants should design the assignment in a creative manner so that students will make use of ChatGPT and its results will get discussed in the classroom. Thus, students will also get the opportunity to use AI tools like ChatGPT. Hence, there will be enhancement in questioning, and 4C's skills.

Most of the participants experimented on the provided prompts from the course. They uploaded their assignments. Thereby they noticed that for the same prompt the ChatGPT has given different responses. Among a few of them discussed and understood the importance of clear and specific prompts and noticed ChatGPT may provide various responses for the same prompt. Discussion on response variability led to the conclusion that for consistent results, users should provide clear and specific prompts and they should be prepared for some level of variation in response as suggested by ChatGPT 3.5. In line with this finding, Stojanov (2023) also identified textual inconsistencies in their autoethnographic study.

Data Analysis and Discussion on Submission of Assignments

During the course the participants were assigned two assignments to assess their proficiency in utilising suitable prompts. The subsequent paragraph analyses and discusses the submission of assignments.

Data Analysis on Submission of Assignments

First assignment was uploaded by most of the participants (80%). While the second assignment was uploaded by a few participants (16.66%).

Discussion on Submission of Assignments

The following section discusses submission of Assignment-1 and Assignment-2.

Discussion on Submission of Assignment-1

The first assignment instructed participants to utilize the provided prompt to design a lesson plan following the STEAM approach and submit their response, along with the outcomes generated by ChatGPT.

The study shows an increase in the number of submissions of the first assignment; it can be attributed to several factors. Participants may have found the first assignment relatively easy; they didn't need to spend much time designing prompts. Another reason could be their convenience in using the prompt as the prompt was already provided in the Session-2.

Discussion on Submission of Assignment-2

The second assignment instructed participants to share innovative applications of ChatGPT in teaching.

Thus, the second assignment focused on the innovation interaction level, which involved creating an artefact. Only a few participants submitted this assignment. Several factors could contribute to this low submission rate. It's possible that they found the assignment challenging, or the course design may have failed to sufficiently engage them. Additionally, it's plausible that the designers of the course did not provide adequate guidance, support (Wang et al., 2014). Or it may be due to some participants not inherently self-directed learners or may lack confidence in their creative skills. While ChatGPT can generate a wealth of ideas and information, effective presentation also relies on strong Pedagogical Content Knowledge (PCK) (Schroeven et al., 2023). Thus, a deficiency in PCK might be another contributing factor that cannot be overlooked.

Discussion on Implementation of Four Interaction Levels of Connectivism Theory

The following Figure-2 gives the idea about the implemented course in the study and the framework for Interaction and cognitive engagement in connectivist learning, based on Wang et al. (2014).



Figure 2: Framework for Interaction and Cognitive Engagement in Connectivist Learning, based on Wang et al. (2014)

The present study shows lower levels of interaction of connectivism theory serve as the foundation of higher levels of interaction. And all the interaction levels are interlinked with each other. The theory demands digital literacy for deeper involvement with the four interactions. Increased interaction occurs among learners, technology, teachers, and content, fostering deeper engagement with both social and informational networks.

The level of cognitive engagement increases as the learners cross each interaction level. In the Operational interaction the participants showed interaction with technology, researcher as a mentor, and the content. In the beginning the participants joined WhatsApp groups, Google Classroom, Sign in ChatGPT, took initiative in discussion and uploaded assignments that showed participants connected with technology. It is in line with the study by Wang et al. (2014) which suggests, operational interaction deals with engagement of the learners with technology as this level serves as a basis for their further learning.

In the Wayfinding interaction the participants showed interaction with technology, learner, mentor, and the content. Thus, it helps to expand the level of interaction and involvement in sensemaking interaction. In the present study it was observed as participants submitted assignments and they participated actively in discussion on variability in responses of ChatGPT. Here it formed the basis of sensemaking interaction. The learner-learner, learner-content, learner-technology and learner-teacher interaction was observed at a deeper sense in sensemaking interaction which helped them to reflect and make decisions.

In the present study the second assignment was based on creativity which is the Innovation Interaction stage. A low submission rate for creating an artifact was noted which may be due to the various aspects as discussed in the above paragraph (Discussion on Submission of Assignment-2).

LIMITATION OF THE STUDY

The study has many limitations, data on a small sample comprising 24 participants, is too small to generalise the findings. Furthermore, while the study did incorporate qualitative data in the form of responses for having the understanding of ChatGPT before and after the course, it might have been constrained. A more thorough qualitative examination, using methods like thematic coding and focus group interviews, will serve a deeper into the experiences of the teachers. Immediate collection of data on the post-course knowledge assessment may not capture the long-term impact of the course on teachers' practices and understanding. Lastly, the limited participation in submitting assignments and engaging in the discussion forum restricted the holistic understanding of the integration of ChatGPT in teaching practices and comprehension. These recognized limitations highlight the potential for future research to explore these areas and to address these gaps.

CONCLUSIONS AND IMPLICATIONS

This ongoing qualitative study sheds light on the significance of training schoolteachers on ChatGPT in an online asynchronous mode based on connectivism theory (Barnett et al., 2013). The study is underpinned by the theoretical framework of connectivism, which offers valuable insights into the essential learning skills and tasks required for learners to thrive in the digital age (Siemens, 2005). The study observed a knowledge gap and misconceptions about ChatGPT in teachers before the course. However, after the implementation of the course a noticeable change was observed in their understanding. They recognized potential benefits of using ChatGPT in their teaching and they found it as a virtual teacher assistant. They recognized the potential of ChatGPT in enhancing the teaching-learning process and reducing their workload (Subramaniam, Apr 1, 2023). However, they also expressed concerns about the ethical implications and the need for human support and guidance in education.

All the prompts in the course on ChatGPT served as a guide for upgrading the skill of prompt engineering. Teachers recognized the significance of prompt engineering in their teaching practices. They acknowledged that for consistent results, it is crucial for users to offer clear and specific prompts and noticed the quality of the prompts significantly affects the quality of the generated content. Additionally, they understood the need to be prepared for some level of variation in responses, as advised by ChatGPT. The study found a direct correlation between cognitive engagement and interaction levels. However, as interaction levels increase, participant involvement tends to decline. The study contributes to the growing body of knowledge on ChatGPT in education. It emphasises the importance of preparing teachers for a paradigm shift in education.

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Appendix-1

Session #	Course Content				
1.	 i) How to install chatGPT? ii) How does ChatGPT generate data? iii) What are the benefits and challenges of using it in the classroom? iv) How does chat GPT help various subject teachers to design their instructional strategies? v) Various Interactive activities for classroom teaching using ChatGPT. 				
2.	 i) What is Prompt engineering ? ii) What is the importance of prompt engineering ? iii) Prompts for- Designing Lesson plans, Getting previous knowledge/ discussion on topic, Creating questions, Creating Study Guides, Creating Cornell Notes, Creating flashcards and Designing 'Think-Pair-Share activity 				
3.	 i) Prompts for- Designing graphic organizers, Designing role play, Designing projects as an group activity ii) Subject specific prompts 				
4.	Prompts for - Creating creativity - (ex. writing stories), Tailoring Rubrics, Using teaching aid, Method, Diagram and Summative assessment.				
Assignments					
1.	Use the given prompt of designing a lesson plan on STEAM approach. Submit the response along with the results generated by ChatGPT.				

2.	Sharing innovative applications of ChatGPT in teaching,		
Discussion forum			
1.	Discuss the advantages of utilizing ChatGPT		
2.	Discuss the variability in responses of ChatGPT		

PREPARING SCHOOL STUDENTS FOR VARIOUS COMPETITIVE EXAMINATION USING ONLINE LEARNING TOOLS AND DIGITAL RESOURCES : OUR EXPERIENCES

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ABSTRACT

The COVID-19 pandemic has compelled educational institutions to adopt online teaching modes to ensure the continuity of education. Online platforms have become essential for conducting classes, sharing resources, assessing student performance, and managing the day-to-day operations of academic institutions. This qualitative study highlights the effective use of online learning tools and digital resources in preparing school students for various competitive examinations, including science competitions, fairs, and exhibitions. Additionally, it discusses the vital roles played by teacher associations, community participation, and strategies to navigate the disruptions caused by the pandemic. Since 2020, the State Level School Competitive Examination Guidance Workshop Organizing Committee, in collaboration with the State Government Education Department, various district science teacher associations, and colleges & research institutes, has been conducting online learning activities on every Sunday. A dedicated YouTube channel (https://www.youtube.com/@-rssp) was established to ensure that students in the remotest parts of Maharashtra receive information and guidance of competitive exams and science-related activities, along with guidance about science competitions, fairs, and exhibitions. Qualitative analysis feedback from students, teachers, and parents of the last three years indicates that the online learning sessions and YouTube channel have provided valuable knowledge, guidance, and motivation for students facing various competitive examinations including science competitions, fairs, and exhibitions. Moreover, this ongoing program has positively impacted many socioeconomically disadvantaged students, fostering their interest in education and increasing their eligibility for various scholarships and advanced career opportunities.

Keywords: Online platform, Competitive examination, YouTube Channel, Google Meet, School students, Teachers Association, School education

INTRODUCTION

In the 4th Industrial Era (4th IR), various educational technologies have become a boon for students and teachers. It offers various learning software, online learning tools and educational digital resources that facilitate classroom teaching and learning. Similarly, online learning resources serve as gateways to vast amounts of knowledge in today's fast-paced and easily accessible world. Online learning resources provide numerous advantages, including improved accessibility and customised learning experiences for students (Dhawan, 2020). For instance, accessing e-books has become much easier than physically visiting a library and searching for desired content. These digital methods also foster increased interest in research, further enhancing the educational experience. With the rapid evolution of technology in education, the need for these materials has never been greater.

Online learning tools and digital resources are vital components of the United Nations' Sustainable Development Agenda 2030, which emphasises the need for inclusive and equitable quality education for all (Our World in Data team, 2023). These technologies have significantly impacted the education system, leading to a paradigm shift in how learning is delivered (Haleem et al., 2022). The COVID-19 pandemic has further institutionalised the use of digital technologies in education, highlighting their role as not only knowledge providers but also as co-creators of information, mentors, and assessors (Deshmukh & Kharade, 2023).

Aim and objective of present study

In this qualitative study, researchers explored the roles of school, teachers, students, parents, teacher associations, community participation, and ways of overcoming the disruptive situation to prepare school students for various competitive examinations, science competitions, science fairs, and exhibitions by using available online learning tools and digital resources. The study explores the following research questions based on secondary data:

- 1. To what extent has the role of school, teachers, students, parents, teacher associations, community participation, in preparing school students for various competitive examinations, science competitions, science fairs, and exhibitions during the disruptive and normal situation?
- 2. What are the available online learning tools and digital resources to prepare school students for various competitive examinations, science competitions, science fairs and exhibitions?

LITERATURE REVIEW

Challenges and opportunities during Covid-19

During the lockdown in 2020, the education sector faced significant challenges as students were deprived of attending schools, colleges, and universities. The situation was dire, and like many countries, India struggled to navigate the pandemic's impact. However, digitalisation emerged as a crucial response, fundamentally transforming the education system. The shift from offline to online learning became necessary, as technology took centre stage in various aspects of life, including education (Dayal, 2023). E-learning platforms proved to be invaluable during this period, providing reliable and informative resources for students, teachers, researchers, and academicians. These platforms facilitated continued learning, allowing students to access content and interact with teachers through virtual classes. Application software such as Google Classroom, WhatsApp, Cisco Webex, Zoom, and Google Meet became essential tools for conducting online classes and meetings.

Despite the advantages of online education, there remains a significant difference between offline and online learning environments. Online education has its pros and cons; while students can study from home and access a wealth of online resources, many faced challenges. Government initiatives played a vital role in supporting students during this transition. However, the rapid shift from traditional learning to an online format left many teachers and students grappling with various obstacles, from lack of internet access to insufficient tools for success in an online setting (Deshmukh & Shrouty, 2022). Often, they had to navigate these challenges with minimal assistance or training, highlighting the need for better support systems in digital education.

Role of Parents, Teachers, Teachers Association, Parent - Teacher Association And Community

A study by Topor (2010) showed that parent involvement significantly impacts students' attitudes, attendance, and academic achievement. Undoubtedly, teacher associations and Parent-Teacher Associations (PTAs) play crucial roles in supporting students and their families while enhancing the overall school experience (Singh, 2014). Undoubtedly, teacher associations provide professional development, networking opportunities, and collaboration for teachers. According to Cowen & Strunk (2015), teacher associations are often structured as professional organisations that support and advocate teachers, fostering opportunities for learning and collaboration. Also, it advocates educators and contributes to shaping school district policies.

PTAs specifically support students in several ways. They enhance academic achievement by facilitating collaboration between parents and teachers, which allows effective monitoring of

homework and resource provision, ultimately improving student performance. Additionally, PTAs contribute to enhancing social development by addressing children's social skills and behavioural issues. They also increase motivation and engagement by fostering a shared sense of educational priority among parents, teachers, and students. Furthermore, PTAs help to build a sense of community by promoting a supportive and inclusive environment. This involvement can lead to an improved school climate, which positively affects learning outcomes. Lastly, PTAs increase parental involvement by encouraging participation in school activities and decision-making processes, thereby strengthening the connection between home and school.

The community plays a vital role in students' education and development, contributing to improvements in schools and neighbourhoods. Community service teaches students to be responsible citizens, fosters critical thinking skills, and helps them build relationships. Similarly, community involvement ensures that students not only acquire academic knowledge but also develop life skills, understand civic responsibilities, and become well-rounded individuals (McAlister, 2013). It also illustrates how their contributions can impact the world. Furthermore, community engagement enables schools to forge strong connections with their surroundings, enhancing the educational experience and providing essential support. School-community partnerships can create a nurturing environment that promotes student learning and success.

Significance of Competitive Examinations, Fairs and Exhibitions

Competitive exams are tests that are used to select candidates for admission, scholarships, jobs, or other purposes. They are usually conducted by various boards, commissions, or organisations at national, state, or institutional levels. The process of preparing for competitive exams not only equips children with academic proficiency but also instils essential life skills. To say that competitive exams are an essential aspect of the school educational system, especially in India, would not be an overstatement. While school exams often come under scrutiny for encouraging rote learning and placing undue pressure on students, the fact remains that exams hold a crucial place in education. However, various competitive exams provide numerous benefits, including building confidence, developing self-analysis skills, promoting healthy competition, and stimulating learning. Competitive exams teach students to manage their time and prepare for future challenges, such as college and professional life. The purpose of competitive exams is not only to judge your talent but also to test your management and planning skills and also be eligible for various scholarships. The whole concept of any competitive exam is based on strategic thinking and smart work.

However, the purpose of science fairs or exhibitions is to instil scientific attitude in students to make them understand the interdependence of technology, science and society. A science exhibition is a wonderful tool that engages students in learning new facts. It helps to develop curiosity in students to learn more, rather than listening to boring traditional lectures. It provides a platform for students to use their scientific knowledge and showcase their best inventions. It also allows students to work together in groups and learn from each other. They share their ideas and collectively galvanise those ideas to bring something innovative into implementation. This further allows the students to develop their social and moral skills and make them a better team player. Students enjoy learning through such exhibitions as they put effort and create models on their own. Presenting ideas in exhibitions helps students to be more familiar with public speaking. This will eventually eliminate their stage fright and imparts self-confidence. It also encourages them to ask more questions to address their curiosities. Science fairs play a crucial role in education by fostering curiosity, critical thinking, and hands-on learning. They provide students with opportunities to explore scientific concepts beyond the classroom, encouraging them to ask questions, conduct experiments, and analyse results independently. In India, the INSPIRE program, or Innovation in Science Pursuit for Inspired Research, has several roles, including to encourage meritorious students to study basic and natural sciences at undergraduate level through attractive scholarship and mentorship opportunities. Olympiads provide immense opportunities for young students to proactively prepare for the competitive exams in the school. Participation in an Olympiad gives students' the opportunity to develop their profile, understand their strengths and focus on key skills to understand the level of competition. NTSE is a National-level exam conducted by NCERT to identify talented students and award them scholarships for pursuing further studies. Vidyarthi Vigyan Manthan (VVM) is an initiative of Vijnana Bharati (VIBHA), in collaboration with the Government of India and NCERT. VVM is a national program with the aim of promoting sciences among school students of standard VI to XI, in search of bright minds with a scientific aptitude.

YouTube and Google Meet

Google Meet offers an interesting feature that allows meeting participants to watch a video on YouTube together, making it a valuable tool for teachers who wish to explain topics through visual content. YouTube is one of the most widely used social media platforms today, boasting 500 million views of learning-related content every day. A notable example of success in this domain is PhysicsWallah, an edtech unicorn that raised \$100 million from top venture capital firms. Other successful educational YouTube channels, such as AsapSCIENCE and Veritasium, cover a range of topics related to general science and science education. However, according to Mayer (2001), one of the primary considerations when constructing educational materials, including videos, is cognitive load. The effective use of video as an educational tool is enhanced when instructors address three key elements: managing the cognitive load of the video, maximising student engagement, and promoting active learning (Brame, 2016).

MATERIALS AND RESEARCH METHODOLOGY

Preparing school students for various competitive examinations, including science competitions, science fairs, and exhibitions, is conducted using Google Meet for guidance sessions and the YouTube channel [RSSP](https://www.youtube.com/@-rssp) to support students. The purpose of this channel is to provide information and guidance about competitive examinations and science-related activities to rural, tribal, urban, and deprived students across Maharashtra. Established on April 14, 2019, the RSSP YouTube channel has garnered 13.9K subscribers and features 176 videos of guidance sessions. This ongoing initiative involves not only school students from grades 8-10 but also teachers, parents, and resource persons as participants. Since 2020, this online learning activity has been conducted every Sunday by the State Level School Competitive Examination Guidance Workshop Organizing Committee in Maharashtra, in collaboration with the State Government Education Department, various district science teacher associations, and members from colleges and research institutes. In this qualitative research, feedback from students, teachers, and parents is collected after every session, and students' questions and answers are recorded to enhance the learning experience.

In this study, the RSSP initiative started a YouTube channel for students to utilise Google Meet and RSSP's YouTube Channel (<u>https://www.youtube.com/@-rssp</u>).

RESULTS AND DISCUSSION

Qualitative analysis of students, teachers, parents, and government officers' feedback showed that this online learning and YouTube channel (https://www.youtube.com/@-rssp) gives students the information, guidance, and motivation to face various competitive examinations. Another advantage is that many socioeconomically deprived students are now taking interest in education, and they are also eligible for various scholarships and advanced career education.

The findings from the RSSP initiative revealed several key insights regarding the challenges and successes associated with the State-Level School Competitive Examination (RSSP) YouTube channel. The coordinator emphasised that the lack of honorariums for guiding teachers poses a significant barrier to attracting high-quality mentors, as educators often prioritise other professional commitments due to financial constraints. Additionally, frequent issues with internet connectivity and electricity have hindered the broadcasting of educational content through YouTube using OBS; however, the collaboration among experts across Maharashtra has been crucial in overcoming these obstacles. The channel's growth to over 13,900 subscribers without advertisements highlights the commitment of proactive teachers united in their intention to provide quality education. The primary goal of the RSSP YouTube channel is to disseminate information about competitive exams and science-related activities to students in remote areas, effectively bridging the information gap and fostering increased interest in education among socioeconomically deprived students. Overall, the insights drawn from the initiative illustrate the challenges faced and the achievements made, emphasising that addressing financial and technical hurdles is essential for enhancing the program's effectiveness. The channel's ability to support students in disadvantaged backgrounds is a testament to the dedication of teachers and the collaborative spirit within the educational community of Maharashtra, making ongoing support for educators and infrastructure improvements critical for sustaining success and expanding reach.

As stated by the teachers, "When we conduct online exams, it is difficult to determine how honest the students are taking the exam. Typically, students from very rural areas do not stay connected for long periods because they face internet issues, and in many cases, the mobile phone is with their father at home. Some students are also in very challenging financial situations. This RSSP program continuously helps them to design science and fairs exhibits, which helps students to learn and grow in many ways."

According to school headmasters/headmistresses, "The most important advantage is that each district has a fixed quota, as well as a fixed caste-wise quota. Earlier, in some districts, students from certain castes were not qualified, and as a result, that district's quota would be transferred to another district. However, this has now stopped, which is a significant achievement. As the information about the above-mentioned exams reached students in remote areas, as well as their mentors and parents, awareness among students increased. Consequently, the percentage of students came for the exams increased. However, since the scholarships and quotas are fixed, the cutoff has increased due to the rise in participation." The school benefited from this as its enrolment numbers increased because students take admission in the physical school to participate in the exams. They also mentioned, "As students' mindset of asking questions and clarifying doubts has increased, teachers now have to prepare thoroughly before teaching."

As said by the parents, "On this channel, government science-related initiatives, science competitions, and the distribution of scholarships to students who achieved ranks were successfully conducted in the presence of distinguished guests and guiding teachers."

According to the education department authority, "Students from economically weaker sections whose families have a combined income of less than ₹3,50,000 (three lakh fifty thousand) can take part in the National Means-Cum-Merit Scholarship (NMMS) examination conducted by the Government of India for students in the eighth grade attending fully funded schools and not residing in hostels. If a student qualifies in the district merit list, they will receive a scholarship of ₹1,000 per month for four years, covering grades nine, ten, eleven, and twelve, amounting to a total of ₹48,000 over four years." For example, if we take the case of Akola district, we can see the number of registrations and eligible students for scholarships in the district during the 2019-20 academic year.

CONCLUSIONS

The qualitative analysis of feedback on the RSSP YouTube channel and its associated online learning initiatives highlight the significant impact on students preparing for competitive examinations. By providing valuable information, guidance, and motivation, the channel has successfully engaged a wide range of learners, particularly those from socioeconomically disadvantaged backgrounds. This increased interest in education has resulted in greater eligibility for various scholarships and advanced career opportunities.

Despite the challenges posed by unreliable internet and electricity, the collaborative efforts of experts across Maharashtra have ensured the successful delivery of educational content. The absence of advertisements on the channel further underscores the commitment of dedicated teachers working with sincere intentions to uplift the educational standards in their communities.

Additionally, the RSSP program plays a crucial role in enhancing students' development through science exhibitions and fairs. It fosters essential skills such as research, communication, creativity, and teamwork while instilling a scientific attitude and problem-solving capabilities. The program not only motivates students to delve deeper into scientific concepts but also highlights the interdependence of science, technology, and society, encouraging a collaborative learning environment among peers and educators.

Furthermore, initiatives like the INSPIRE program provide meritorious students with the necessary support to pursue basic and natural sciences at the undergraduate level. By offering attractive scholarships and mentorship opportunities, INSPIRE aims to cultivate the next generation of innovators and researchers.

In summary, the combination of the RSSP YouTube channel and programs like INSPIRE significantly contributes to the holistic development of students, empowering them to face challenges in their academic journeys and beyond.

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STEM EDUCATION IN RURAL MALAYSIAN SCHOOLS: REVIEWING CHALLENGES AND THE ROLES OF TERTIARY EDUCATION INSTITUTIONS

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ABSTRACT

In pursuit of its aspiration to become a fully developed nation by 2030, Malaysia has integrated on Science, Technology, Engineering and Mathematics (STEM) education in all tiers, from pre-school to tertiary level. While key initiatives have been planned and executed within the past decade, disparities remains in the implementation of STEM-based education between rural and urban schools. This paper is part of an exploratory study aimed to identify the challenges faced in developing STEM education in rural environments in Malaysia. A narrative literature review was employed to meet the research objectives. The findings suggest that local universities and colleges should play bigger roles in assisting in the improvement and enhancement of current initiatives for STEM education in Malaysia, particularly in rural schools.

Keywords: STEM, rural, education, challenges, Malaysia

INTRODUCTION

STEM education is crucial for Malaysia's goal of becoming a developed nation. The New Economic Model (NEM) aims to create 1.3 million STEM-related jobs, requiring a strong STEM workforce. Malaysia's STEM framework aims to develop STEM literacy from early childhood through tertiary education. STEM education is essential for Malaysia's development, especially in keeping pace with advancements in science and technology. Key initiatives include fostering curiosity in primary schools, problem-solving in lower secondary through revised curriculum, and conducting STEMrelated activities in schools to motivate and prepare students for STEM careers at the upper secondary and tertiary levels. (Khairani, 2017; Mohd Shahali et al., 2017; Zaiton et al., 2019; Razali et al., 2020). However, the trends of STEM student enrolment in STEM courses in the past decades have been stagnantly low. Figure 1 shows the STEM enrolment statistics in Malaysia from 2016 - 2024 (Ministry of Education, Malaysia, 2024). While activities aimed at increasing this percentage have been intensified, disparities still exist in the implementation and acceptance of STEM education in rural schools compared to urban schools. Therefore, the objectives of this study are twofold: (1) this paper explores the challenges of implementing STEM education in rural schools, offering insights into the situations faced by rural schools in Malaysia; (2) The present study also underlines the possible role of local higher learning institutions in the development of STEM education.



Figure 1: Statistics of STEM enrolment in Malaysia from 2016 - 2024 (Source: Ministry of Education Malaysia, 2024)

METHODOLOGY

This study employs a narrative review method as the primary approach for gathering the data. The method allows the researchers to describe what is known about a particular research topic by performing a subjective investigation and critique of the current literature (Suhera, 2022). Moreover, it allows the researchers to describe the current trend of a research topic (Rumrill & Fitzgerald, 2001), which can provide future study directions. The narrative review method used in the study consisted of five rigorous steps as highlighted by Suhera (2022). The first step is to frame a research question or study objective, as mentioned in the introduction section. The second step is to set the clarity of boundaries. The literature on the challenges of STEM education spans across all countries. Therefore, the boundaries to search for relevant research articles were set to only include studies published in rural Malaysian schools. The next step is to justify the inclusion and exclusion criteria. In this step, the research articles were obtained from SCOPUS and WOS databases due to publication quality. Moreover, only STEM research articles on rural Malaysian schools' context were selected. Seven research articles were included in this review after the inclusion and exclusion step (see Table 1 for the list of research articles). The fourth step is regarding the reflexivity statement in which this research does not aim to be inclusive of all literature addressing the topic of interest. The final step is analysis and interpretation to meet the research objective as discussed in the findings section.

FINDINGS

The study is based on a narrative review of seven past studies obtained from two databases. Two objectives set at the start provide a guideline for the discussion of the findings. The first part of the findings highlights the challenges of STEM education in Malaysian rural schools, whereas the subsequent part presents the discussion on the role of tertiary education in STEM education development.

Challenges of STEM Education in Malaysian Rural Schools

One significant report that highlighted the challenges faced by rural schools in STEM education was by Khairani (2017). The study assesses the differences in competency for STEM integration education

between urban and rural teachers in Malaysia, focusing on their readiness to implement educational reforms in STEM education. The author pointed out the declining percentage of STEM enrolment in schools which hampered the then-current national goal of producing 500,000 scientists by 2020. There were disparities between urban and rural schools, and among the reasons suggested were the digital divide, lack of resources in rural areas, and low teachers' competencies in teaching STEM-related subjects (Khairani, 2017). Similar concerns were addressed by other researchers. In a review on the policy and initiatives for the implementation of STEM education in Malaysia, Mohd Shahali et al. (2017) raised concerns about the quality of teachers and the need for better resources to ensure more effective teaching and learning of science subjects. The study by Ahmad et al. (2017) reported that teachers in rural areas do not have the competency to integrate STEM education into the learning and teaching system. Research by Amirah et al. (2018) showed that there are significant weaknesses in the use of STEM in schools, especially in rural areas, which include teaching and facilitation methods, especially for teachers and students. Disadvantages of STEM applications for rural areas include teaching methods and classroom programming (Abdul Rahman & Surat, 2019). Teachers face issues such as lack of facilities, incomplete laboratory setups, limited access to STEM teaching materials, and insufficient guidance on STEM teaching methodologies (Jamaludin et al., 2020).

There have been various initiatives to foster STEM interest in rural schools (Zaiton et al., 2019; Abdul Rahman & Surat, 2019; Jamaludin et al., 2020; Idris et al., 2023a; Idris et al., 2023c). STEM modules were developed to cater for rural schools, with the aim of improving students' interest towards STEM. At the same time these modules were designed to assist teachers in improving the teaching and learning of science and mathematics (Zaiton et al., 2019; Jamaludin et al., 2020); Azman et al., 2021).

Latest findings highlighted that incomplete equipment and facilities for teaching represent a significant barrier in fully implementing STEM education in secondary schools in general. Inadequate resources, coupled with a shortage of trained teachers, present hurdles to the adoption of STEM education, hindering the cultivation of future scientists, engineers, and technologists. (Riduan & Othman, 2024). Table 1 summarizes the challenges faced by Malaysian rural schools in the implementation of STEM education.

Research Article	Research Findings
Khairani (2017)	Digital divide, lack of resources, and low teachers' competencies
Shahali et al. (2017)	Quality of teachers and the need for better resources
Ahmad et al.(2017)	Lack of competency among teachers in rural areas
Amirah et al. (2018)	Weakness in teaching and facilitation methods
Abdul Rahman & Surat, (2019)	Ineffective teaching methods
Jamaludin et al., (2020)	Lack of facilities, and insufficient guidance
Riduan & Othman (2024)	Inadequate resources, shortage of trained teachers

Table 1. The Challenges of STEM Implementation in Rural Malaysian Schools

Roles of Tertiary Education Institutions in STEM Education in Rural Schools

Local universities and colleges play a pivotal role in assisting the development of STEM education in Malaysia, particularly in rural areas. Based on the challenges identified from past research, it is suggested that local higher learning institutions can increase their efforts in improving STEM education in rural areas through university-schools collaboration. This may be done through regular activities to promote STEM, focusing on rural schools, and by the development of teaching modules that could provide teachers with better guidance and resources.

Increase STEM partnerships between rural schools and higher institutions

The framework for STEM education includes action plans to integrate formal, non-formal, and informal STEM education and increase student participation in STEM fields. The plan includes initiatives like mentorship programs, and outreach activities (Mohd Shahali, 2017). STEM Mentor-Mentee program can increase students' interest in STEM through hands-on activities and mentoring by

university students and lecturers (Azman et al., 2021). Motivating students in science plays a critical role in developing their interest in STEM fields. Students' interest in STEM-related careers can be explained by their motivation, particularly intrinsic motivation, and curiosity to learn science (Razali et al., 2020; Ahmad & Siew, 2021). Activities should develop keen interests among school students towards STEM education, through exploring the various scientific fields, technology, and career aspirations. This can be possible with the presence of strong collaboration between universities/colleges and schools.

Enhance STEM teachers' competency through the university's module

Many teachers, particularly in rural areas, are not fully equipped with the necessary competencies and technological skills to teach STEM subjects effectively. Urban teachers show higher competency in incorporating information and communication technology (ICT) into their teaching compared to rural teachers due to better access to technology and infrastructure. These factors pose challenges for the successful integration of STEM education in rural schools (Khairani, 2017). While universities or colleges may not be able to contribute to capacity building in rural schools, they can utilize their resources and expertise to develop STEM modules that are aligned with the existing curriculum, and flexible for use in schools and at home. The modules should also incorporate hands-on learning, practical, user-friendly, engaging not just students, but also parents and the rural community in supporting STEM education (Jamaludin et al., 2020; Idris et al., 2023a). A well-designed STEM module should address the specific needs of rural schools, provide practical resources, and enhance teacher training. Such teaching interventions can assist in changing teachers' perceptions of teaching STEM education in rural areas.

CONCLUSION

The successful implementation of STEM education in rural Malaysian schools are hindered by the lack of infrastructure, relevant facilities and resources to guide and improve the competencies of teachers, as compared to urban schools. Future efforts need to focus on enhancing STEM curricula, teacher professional development, and STEM activities to increase interest in STEM among students. These efforts can be enhanced through collaboration between teachers and universities/colleges, with the aim of improving students' interest in science, their performance in STEM-related subjects, as part of a continued effort to overcome the obstacles faced by rural schools and ensure Malaysia's progress towards a fully developed nation.

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NAVIGATING ETHICAL CONSIDERATIONS WITHIN EVOLVING EDUCATIONAL TECHNOLOGIES: FRAMEWORK FOR HIGHER EDUCATION IN INDIA

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ABSTRACT

The constant urge to innovate education with new and more effective strategies and tools has brought technology into the forefront of education. The increasing use of technology can lead to its imposition, compromising ethical considerations involving the fair use of technology, focusing on privacy, equity, implementation and transparency. While EdTech promises enhanced learning experiences through personalization and accessibility, its potential benefits can be overshadowed by ethical concerns. This conceptual study aims to delve deeper into the ethical considerations necessary within the evolving educational technologies, focusing on the Indian context. The study outlines the ethical challenges and concerns of educational technologies considering the use of Artificial Intelligence (AI), equity issues, and the digital divide in higher education in India. Through review of current literature, we identify significant ethical gaps that affect the users. We propose a framework for ethical decision-making in EdTech implementation, emphasizing principles of inclusivity, transparency, accountability, and privacy. Consequently, relying on ethical, educational, and technological stances, this scholarly endeavour provides a conceptual map to understand the ethical dilemma that is invariably embedded in AI in the learning process. It underlines the relevance of building procedural transparency, independent accountability, as well as equality to ensure that AI is an enabler of education's aims to contribute to a student's success as well as the general well-being of a society. In an effort to evaluate qualitatively the complexity of the problem, design an ethical framework, and implement appropriate best practices for pedagogical use of AI-based technologies in education, this paper seeks to provide policymakers, educators, and technology developers with guidelines that will foster an ethical cautious future use of AI in educational spaces.

Keywords: Education technology, Framework, Ethical Considerations, Digital Divide, Higher Education

INTRODUCTION

The vision of Society 5.0 and the 4.0 Industrial Revolution are the topic of discussion in many fields of education in the 21st Century. No doubt, the synergy between the industrial revolution 4.0 and society 5.0 gives a new perspective in the learning process (Dev Sanskriti Vishwavidyalaya, Haridwar (Uttarakhand), India. et al., 2020). The integration of educational technology (EdTech) into higher education is transforming the academic landscape both in India and globally. Higher education institutions are increasingly adopting technological tools to enhance learning experiences, improve administrative efficiency, and broaden access to educational resources (Mohamed Hashim et al., 2024). This integration of technology in educational settings raises ethical considerations such as privacy concerns related to student data, ensuring equitable access to technology for all students, addressing potential biases in algorithmic decision-making, and fostering responsible digital citizenship.

Status Of Higher Education in India And Globally

In developing countries, particularly in rural areas, the application of educational technology (EdTech) in schools faces significant challenges. These include infrastructural inadequacies like unstable electricity and internet connectivity, economic constraints limiting budgets for purchasing and implementing EdTech tools, and a lack of technical expertise among educators and administrators. Additionally, cultural resistance to new technologies, non-contextual educational content, and language barriers further complicates the adoption process (Kamat & Nasnodkar, 2019).

However, in the realm of higher education, there is relatively greater exposure to EdTech. This exposure is not only limited to teaching and learning processes but also extends to other academic activities, such as using technology for writing papers. This includes addressing issues like plagiarism, copyright infringement, and obtaining consent for photos intended for publication. Given these complexities and the more widespread use of technology in higher education, this study focuses on the ethical considerations of EdTech in this context, particularly within India.

In India, higher education is undergoing significant reform and expansion, making it the third-largest system globally, after the USA and China. With a growing number of universities and numerous colleges, the sector strives to accommodate a burgeoning student population. However, despite these advancements, challenges persist, including disparities in access to resources, varying quality of education, and limited integration of technology (Khan & Mohakud, 2020). These issues are compounded by global challenges faced by higher education, such as inequity, disinvestment, disparities in access to resources, varying quality of education, and limited integration of technology persist (Marín & Tur, 2024).

Globally, higher education faces similar issues, though the extent varies by region. Developed countries typically have more advanced EdTech infrastructure, while developing nations, including India, are in various stages of adoption and integration (Lallez, 1986).

Educational Technology (Edtech)

EdTech refers to the use of technology to support and enhance educational processes. It encompasses a wide range of tools and applications, including learning management systems, online courses, educational apps, and artificial intelligence (AI)-driven platforms (Aydin, 2024; Saxena & García, 2023). EdTech aims to personalise learning, make education more accessible, and streamline administrative functions. However, as its use grows, so do concerns about how these technologies are implemented and their impact on educational equity and privacy (Marshall et al., 2022).

Ethical Concerns in Edtech

The increasing reliance on EdTech raises several ethical issues. Key concerns include privacy and data security, the digital divide, intellectual property rights, and the potential for misuse of technology (Khan & Mohakud, 2020; Laufer et al., 2021). Ensuring that technology enhances rather than hinders educational outcomes requires careful consideration of these ethical dimensions (Lossec & Millar, 2021). The potential for exacerbating existing inequalities and the need for transparent and accountable technology use are critical areas of focus.

This study aims to explore the primary ethical concerns that arise with the integration of educational technologies in higher education, focusing particularly on the Indian context. It seeks to understand the challenges related to privacy, equity, and data security that emerge as technology becomes increasingly embedded in educational practices. Additionally, the research will investigate how a structured framework can be created to address these concerns and guide the ethical deployment of EdTech. The goal is to develop practical solutions and recommendations to ensure that educational technologies are used responsibly, fostering a more inclusive and equitable learning environment. This will also guide policy makers and decision makers to pay more attention to ethical concerns in EdTech.

METHODOLOGY

This study adopts a qualitative approach, focusing on a systematic review of literature and existing frameworks related to ethical considerations in educational technology (EdTech) within Indian higher education. An extensive search was conducted using databases such as Google Scholar and JSTOR, targeting keywords like "educational technology," "ethics in EdTech," and "higher education in India." The literature was analysed thematically, identifying key ethical concerns such as privacy, equity, and data security.

Based on the findings, a conceptual framework was developed, incorporating insights from established models like Dyson's mobile learning framework and Holmes' AI ethics framework (Holmes et al., 2022; Wishart, 2018). This integration guided the design of a framework tailored to address the specific ethical challenges in the Indian higher education context, ensuring that EdTech implementation is both responsible and equitable.

Ethical Considerations Within Edtech: A Framework For Higher Education In India

Several existing frameworks address ethical considerations in educational technology (EdTech), each offering unique perspectives and guidelines for responsible implementation. One such framework is Laurel E. Dyson's "Towards a Holistic Framework for Ethical Mobile Learning," which emphasises the importance of learner agencies in mobile learning (M-learning) (Wishart, 2018). This framework recognizes the diverse needs of learners, including those in developing countries and Indigenous communities, and advocates for responsible mobile use policies. It encourages co-development of these policies with students and other stakeholders to promote a sense of ownership and ethical behaviour. The framework stresses the importance of institution-wide dissemination, training, and implementation of M-learning policies, with regular updates to address evolving ethical concerns. It also highlights the need for culturally appropriate practices, mobile etiquette, and training for educators, administrators, and ICT personnel to respond to unethical behaviour, ensuring a positive ethic of responsibility in all educational settings.

Another significant framework is "Ethics of AI in Education: Towards a Community-Wide Framework" by Wayne Holmes and colleagues, which addresses the ethical implications of using Artificial Intelligence in Education (AIED). This "strawman" draft framework emphasises a community-wide approach to ethics in AI, focusing on data privacy, transparency, accountability, and security (Holmes et al., 2022). It underscores the necessity of equitable access to AI technologies and the appropriate attribution of AI contributions. The framework calls for developing AI literacy among educators, students, and administrators while advocating for a balanced approach to AI adoption. It also stresses the importance of continuously monitoring and evaluating AI implementations to ensure they align with ethical standards and do not exacerbate existing inequalities within educational settings.

The "Comprehensive AI Policy Education Framework for University Teaching and Learning" by Cecilia Ka Yuk Chan offers a more detailed perspective, covering three dimensions: Governance, Pedagogical, and Operational. The Governance Dimension involves senior management's role in understanding and preventing academic misconduct and ethical dilemmas related to AI, ensuring data privacy and transparency, and promoting equity in AI access (Chan, 2023). The Pedagogical Dimension focuses on developing holistic competencies in students, preparing them for an AI-driven workplace, and advocating for a balanced approach to AI adoption in educational contexts. The Operational Dimension emphasises the need for rethinking assessments, providing training and support for AI literacy, and consistently monitoring the impact of AI on teaching and learning processes.

These existing frameworks form the foundation for our proposed framework, providing essential insights and guiding principles. For instance, Dyson's emphasis on learner agencies and responsible mobile use policies informs our approach to promoting inclusivity and student engagement. Similarly,

the community-wide perspective on AI ethics from Holmes and colleagues, with its focus on data privacy and transparency, serves as a crucial reference point for ensuring accountability and ethical use of AI technologies. Chan's comprehensive framework, addressing governance, pedagogical, and operational dimensions, underlines the importance of a holistic approach to managing and implementing EdTech.

By building on these established frameworks, our proposed framework aims to address the unique challenges and needs within the Indian higher education context. We seek to fill gaps in the current literature by offering practical recommendations for overcoming the digital divide, ensuring ethical use of technology, and safeguarding student data. This integration of existing knowledge with a focus on India's specific socio-economic and cultural landscape provides a comprehensive guide for promoting equitable and responsible EdTech practices.

RESULTS AND DISCUSSION

The framework conceptualized based on existing literature, addresses various aspects of ethical considerations in EdTech, including the challenges that arise, the importance of ethical considerations when adopting EdTech, and recommendations for shaping education policies (see Figure 1). It emphasizes ensuring the ethical use of educational technologies to safeguard the well-being of students, educators and all other users. This includes maintaining privacy, securing data, and fostering an inclusive learning environment. It also underscores the importance of respecting intellectual property rights and preventing issues such as cyberbullying.

The elements of the framework are the need for ethical Guidelines in higher education in India, in the context of higher education in India, the framework highlights the unique challenges posed by the country's diverse socio-economic and cultural landscape. These challenges necessitate a comprehensive set of ethical guidelines to ensure that all students have equal opportunities to benefit from technological advancements. The equitable implementation of educational technologies is a significant concern, as there is often a digital divide that can limit access to resources for students from disadvantaged backgrounds. The framework calls for policies that address these disparities, ensuring that all students have access to the necessary technology and resources.

The ethical considerations in the adoption of educational technologies includes the competence and qualification of educators, stressing the need for regular assessments to ensure they possess the necessary skills and understanding of ethical implications in technology use. It highlights the importance of respecting copyright and intellectual property rights, preventing cyberbullying, and ensuring data privacy and security.

There are several key challenges in addressing ethical considerations, such as the lack of awareness and understanding of ethical issues, the rapid advancement of technology, and the need for legal and regulatory compliance. These challenges require continuous learning and professional development for educators, as well as adaptation in legal frameworks to protect the rights and privacy of all individuals involved in the educational process.

Lastly, the framework includes recommendations for ethical guidelines in higher education in India formulating clear policies and guidelines, providing professional development and training programs, fostering collaboration and sharing best practices, and implementing monitoring and evaluation mechanisms. These measures aim to ensure that ethical considerations remain a priority as technology evolves, ultimately supporting the responsible and equitable use of educational technologies in higher education in India.



Figure 1: Framework for ethical considerations in EdTech for higher education in India.

CONCLUSIONS

The conceptual framework can be valuable as it addresses the ethical considerations in EdTech within higher education in India. Given the current lack of study and research on this topic, the framework can serve as a foundational guide. Future revisions and enhancements can further refine and adapt the framework to evolving ethical challenges and technological advancements in the field.

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EXPLORING THE ISSUES OF STEM EDUCATION IN SARAWAK

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ABSTRACT

The three transformation waves of Malaysia's STEM education initiatives, aimed at strengthening STEM education, are set to conclude in 2025. However, STEM education in Sarawak remains behind these transformation waves. An exploratory study on STEM education in Sarawak was conducted, involving stakeholders from 1,224 primary and secondary schools. The schools were selected using a multistage sampling method, and qualitative data were gathered from 1,526 interviews. The study also included three focus group discussions with a total of 24 participants. Descriptive and content analyses were performed. The study identified 42 issues related to STEM education in Sarawak, which were categorised into seven areas of concern: school instructional leadership, teaching and learning, student academic performance, resources, and facilities, enrolment of students in the STEM package, co-curricular activities in STEM, student enrolment in STEM programs, and community participation in education.

Keywords: STEM Education, issues, areas of concern

INTRODUCTION

The new millennium demands human capacity equipped with 21st-century skills. Science, technology, engineering, and mathematics (STEM) education fosters these skills by nurturing students to solve complex problems innovatively, preparing them for the global market. Students need a combination of creativity, higher-order thinking, and innovative skills to address these challenges (Ho, Subarna, & Pham, 2021). This approach is a sustainable way to enhance students' competency levels in STEM (Allina, 2018).

Malaysia's education system emphasises STEM education as a key component of the country's policies and strategies. Since the 1970s, Malaysia has focused on STEM education to develop human capacity and strengthen the economy. Numerous efforts have been made to improve the quality of STEM education (Kamisah Osman, 2014). Issues in STEM education identified in the literature include students' lack of interest in STEM subjects (Mohd Shahali et al., 2019), fear and lack of confidence in pursuing STEM (Ismail et al., 2019), and a lack of motivation to learn Science (Razali et al., 2019). Additionally, students face insufficient exposure to the daily application of STEM (Jaafar & Maat, 2020) and limited exposure to STEM career fields (Vela et al., 2020). Teacher-related issues include a lack of teacher knowledge related to STEM (Shahali et al., 2017), imbalanced STEM (Thibaut et al., 2018). There are also issues with inadequate equipment (Belalang & Abd Rahman, 2016) and a lack of sufficient equipment in school laboratories (Clyton & Moses, 2017).

The initiatives to strengthen STEM education by the Ministry of Education Malaysia are structured into three waves as stated in the Malaysian Education Blueprint 2013-2015. The first wave (2013–2015) focused on strengthening foundational knowledge. The second wave (2016–2020) aimed to build on this foundation, while the third wave, "Innovating to the Next Level," is scheduled for 2021 to 2025 (Ministry of Education, 2013, p. E-9). Currently, Malaysia's education system is approaching the end of the third wave initiative. A baseline study on STEM education in Sarawak reported that STEM education in the region continues to lag behind the progress made during the first and second waves (Ling et al., 2021). Therefore, a study to identify the issues within STEM education is needed.

METHODOLOGY

The study employed an exploratory approach. The population of the study consisted of school administrators, teachers, and parents from 1,224 primary and secondary schools in Sarawak. A multistage sampling method was used to select the schools. The schools were categorised based on the divisions of Sarawak, and schools in each division were further divided into primary and secondary levels. For each level, schools were selected based on five categories defined by the Sarawak Education Department: urban, rural, interior 1, interior 2, and interior 3. A total of three focus group discussions with 24 participants and 1,526 interviews were conducted. The qualitative data were transcribed from the recorded audio, and the issues were explored by grouping similar issues into themes.

RESULTS AND DISCUSSIONS

The study identified 42 issues, which were categorised into seven areas of concern related to STEM education in Sarawak. The first area of concern is School Instructional Leadership, with two issues. The first issue is that school administrators did not prioritise engaging parents and communities, and the second issue is the absence of effective teaching supervision by senior leadership teams at schools. The second area of concern is Teaching and Learning with 8 issues. The issues are teachers' and students' 21st-century skills are at low to moderate levels, teachers face difficulties in implementing individualised teaching approaches in the classroom for mixed–ability students, various teaching methods are not fully utilised to maximise the teaching of STEM, teachers still predominantly use teacher–centred approach, assessments for learning (student's self–assessment and peer assessment) are not carried out as expected, non–option STEM teachers have less content and pedagogical knowledge, insufficient integration of blended learning tools and platforms in teaching, and exhibit slightly negative attitudes and low enthusiasm toward teaching STEM subjects in English.

The third area of concern is Students' Academic Performance with 8 issues. The first five issues are students' self-confidence towards learning STEM subjects is at low to moderate level, motivation level towards learning STEM subjects is moderate, academic engagement in learning STEM subjects is at a moderate level, self-assessment (classroom assessment) is below expectation and critical thinking skills, self-directed skills, and higher-order thinking skills are at a moderate level. Students from lower socio-economic backgrounds performed lower academically and those from rural and interior schools have low academic performance in STEM subjects. The last issue is students believed that Science and Mathematics are difficult subjects.

The fourth area of concern is Resources and Facilities. A total of 10 issues were categorised under this area of concern. The issues are insufficient number of visual aids for teaching and learning, insufficient allocation of science materials, apparatus, and instruments, limited resources for teaching STEM, particularly in terms of hands-on materials, lack of structured online resources for STEM teaching and learning, very limited or poor internet access, especially in rural and interior areas, in terms of both coverage and speed, shortage of Science and Mathematics option teachers, insufficient number of laboratory assistants, science support staff and computer technicians, resource rooms or libraries in many schools lack reading materials and the existing resources are outdated, and the majority of primary schools especially in the rural and interior areas do not have a science laboratory.

The fifth area of concern is the Enrolment of Students in STEM Package with 4 issues identified. The study found low to moderate exposure to STEM experience outside the classroom, STEM self-efficacy in performing tasks related to the engineering components of STEM, and interest towards STEM-related careers. The last issue is students' apprehension toward pure science subjects and additional mathematics. The sixth area of concern is Co-Curriculum Related to STEM which includes 7 issues. The issues are teachers in charge of STEM-related clubs lack sufficient knowledge to conduct STEM-related activities, STEM-related co-curricular activities are limited,

and very few extend beyond classroom learning, STEM activities and competitions are mostly exclusive to selected high performing students, STEM activities and competitions are mainly conducted in urban areas, STEM co-curricular activities are predominantly competition-oriented, limited resources to run STEM-related clubs especially in rural and interior schools, and the influence of co-curricular activities on academic performance in STEM subjects is moderate.

Community Participation in Education is the seventh area of concern. The 3 issues categorised under this area are lack of support from parents and communities in children's education, parents and communities have negative perceptions of STEM subjects, and most rural and interiors parents delegate the responsibility of their children's learning to schools.

The 42 issues identified in STEM education in Sarawak highlight the reasons behind the first two waves of initiatives aimed at improving STEM education in Malaysia. Some of these issues are consistent with those identified in the literature (Belalang & Abd Rahman, 2016; Clyton & Moses, 2017; Ismail et al., 2019; Jaafar & Maat, 2020; Khairani, 2017; Mohd Shahali et al., 2019; Razali et al., 2019; Shahali et al., 2017; Thibaut et al., 2018; Vela et al., 2020).

CONCLUSIONS

The present study explores the issues of STEM education in Sarawak. A total of 42 issues related to STEM education in Sarawak were identified and categorised into seven areas of concern. To align with the initiatives launched by the Ministry of Education Malaysia, these issues need to be resolved as soon as possible. A total of 98 resolutions were recommended, with 10 for School Instructional Leadership, 28 for Teaching and Learning, 11 for Students' Academic Performance, 23 for Resources and Facilities, 3 for Enrolment of Students in STEM Package, 13 for Co-Curriculum Related to STEM, and 10 for Community Participation in Education.

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ENHANCING STUDENT LEARNING OUTCOME IN STEM THROUGH SERVICE-LEARNING MALAYSIA-UNIVERSITY FOR SOCIETY (SULAM)

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ABSTRACT

Service Learning Malaysia-University for Society (SULAM) is a course-based, credit-bearing educational experience in which students participate in a structured service activity that meets identified community needs, reflect on service activity and experiences to achieve desired learning outcomes. It is an approach for students to gain deeper understanding of course content, broader appreciation of the discipline, enhanced sense of personal values and civic responsibility. The Plantation Crop Mechanization Course included SULAM designed by integrating STEM for Semester Six students from Universiti Teknologi MARA, Sarawak Branch was carried out for a Primary School level pertaining to modernisation of rice production. From the assessment conducted, the pupils agreed the service activities were very useful for inclusion in course content. The experience had contributed a lot to their learning enhancing competencies. Their degree of participation satisfaction was very high. All the three elements obtained a mean of 4.5 in a 5-rating scale.

Keywords : SULAM, Service Learning, society, STEM

INTRODUCTION

Service Learning Malaysia-University for Society (SULAM) is a course-based, credit-bearing educational experience in which students participate in a structured service activity that meets identified community needs, reflect on service activity and experiences to achieve desired learning outcomes (Ministry of Education, Malaysia, 2019). It is an approach for students to gain deeper understanding of course content, broader appreciation of the discipline, enhanced sense of personal values and civic responsibility. SULAM is also one of the elements that characterizes High Impact Educational Practices within the curriculum of academic programme, a practice introduced by the Ministry of Higher Education Malaysia in 2016. The objectives are formulated with hopes of enhancing the knowledge, skills and competences of students in their respective disciplines of fields and forming students' 21st Century Soft skills.

From the students' perspective, the hands-on learning experiences in SULAM attract prospective students and improve overall educational quality (Johan et al., 2022). In addition, it can enhance student learning and development; allowing students to apply theoretical knowledge gained in the classroom to real-world scenarios (Naufal et al., 2024). From the community perspectives, Mokthsim (2023) highlighted 3 areas:

• SULAM empowers communities by providing access to expertise, knowledge, and innovative solutions.

• Community members gain new skills, resources, and support, enabling them to tackle challenges and achieve their goals more effectively

• Fosters social change by addressing systemic issues and promoting sustainable development.

Wahab (2024) concluded from his evaluation study that underscored SULAM's dual benefits: it enriches student learning through real-world application and fosters a sense of civic duty, while also providing valuable services to communities.

In the pursuant of a Bachelor of Science (Hons) in Plantation and Technology Management in Universiti Teknologi MARA, Malaysia, the Plantation Crop Mechanization, a course-based, creditbearing educational experience in which students participate in a structured service activity that meets identified community needs, reflect on service activity and experiences to achieve desired learning outcomes is embedded with SULAM. This is an approach for students to gain deeper understanding of course content, broader appreciation of the discipline, enhanced sense of personal values and civic responsibility. The student community service activities integrated into an academic course, utilises the service experience as a platform for both academic learning and civic learning as shown in the model on the key components of SULAM in Figure 1.



Figure 1: Key components of SULAM (Department of Higher Education, 2019: adapted from Furco (1996)

The advocacy component of the SULAM was on educating others about topics of public interest. The activity integrated the Science, Technology, Engineering and Mathematics (STEM) was carried out in SMK Gedong pertaining to modernisation of rice production. The school was chosen as Gedong is in the hub of Sarawak's main producer of hybrid paddy seeds. This paper reports on the perception of Semester six students evaluating their experience after taking the project.

METHODOLOGY

A quantitative research approach, utilizing a service learning structured questionnaire adapted from Folgueiras et al. (2014) on three elements: perception of service, competence and satisfaction was disseminated through google form. The survey instrument was divided into 4 main sections: Part A pertained to demographic information with 3 questions on age, gender and current working status. Part B related to program service with 2 questions using a scale of 1 (not at all) to 5 (A lot) and 13 questions on the extent the service activities that were carried out with a scale of 1 (not useful at all) to 5 (very useful). Part C was on competences with 1 question on extent the work on this project had contributed to their learning in the subject and/or studies that the students were taking using a scale of 1 (not at all) to 5 (A lot) and 21 questions on the degree to which your Service Learning project has contributed to developing the following transversal competences with a scale of 1 (not useful at all) to 5 (very useful). Part D was on participations with 6 questions regarding their extent each of these reasons motivated them to take part in this project with a scale of 1 (not at all) and 5 (very useful) and their satisfactions measured with 13 questions with a scale of 1 (not at all) to 5 (A lot).

The collected data were analysed using IBM SPSS software. Descriptive statistics were employed to interpret the results.

RESULTS AND DISCUSSIONS

Demography Information

Out of the 21 graduates, 13 responded with 3 out of 8 females and 10 out of 13 males. Further investigation indicated that 3 of the males who did not respond were already with full time jobs in the oil palm plantation estates who could not access the online google survey due to poor internet connectivity. Only 2 respondents were 25 years old while 11 respondents were 24 years old. Only 2 male respondents and 2 female respondents were also not working while the rest were on full time jobs since graduating in February 2024.

Service

The service that was offered aimed at the secondary school students with STEM components with awareness-raising activity to modern agriculture in paddy cultivation. Table 1 shows the majority of the respondents indicated the usefulness of SULAM in the course content and addressed a real need.

Tuble 1. Extent of service derivities being useful and fear need to the target group							
Extent the service activities that were carry out	Scale (%)						
1 (Not at all); 5 (A lot)	3	4	5	Mean			
Useful for inclusion in course contents	0.0	38.5	61.5	4.6			
Address a real need	15.4	30.8	53.8	3.9			
			Overall Mean	4.3			

Table 1: Extent of service activities being useful and real need to the target group

Table 2 indicates the extent to which the service activities that were carried out have been useful to students who delivered the SULAM activities. In general, the perception towards 11 questions were consistent with a mean of above 4.5. Pertaining to a factor of encouragement to take part in the life of the faculty, neighbourhood or town has one respondent indicating not so useful is contrasting to the findings of Mokthsim (2023) and (Naufal et al., 2024). Similarly, it was unexpected that Be more motivated to study scored the lowest mean of 4.

Table 2: Extent to which the service activities that were carried out have been useful to students who delivered the SULAM activities

Extent the service activities that you carry out	Scale (%)					
1: not useful at all; 5: very useful	2	3	4	5	Mean	
Understanding social needs	0.0	0.0	61.2	38.5	4.4	
Understanding some course content in more depth	0.0	0.0	46.2	53.4	4.5	
Working with an organisation	0.0	7.7	38.5	53.8	4.5	
Awakening interest in social problems	0.0	7.7	46.2	46.2	4.4	
Encouraging me to take part in the life of the faculty, neighbourhood or town	7.7	0.0	31.6	61.5	4.4	
Be more motivated to study	7.7	0.0	38.5	53.8	4.3	
Learning course contents	0.0	0.0	38.5	61.5	4.6	
Being more responsible for my own actions	0.0	0.0	15.4	84.6	4.8	
Contributing to a better society	0.0	0.0	53.8	46.2	4.5	
Establishing relationships between theory and practice	0.0	0.0	30.8	69.2	4.7	
Getting to know the professional field related to my degree	0.0	0.0	38.5	53.8	4.5	
Analysing and reflecting on course content	0.0	0.0	46.2	53.8	4.6	
Developing values	0.0	0.0	30.8	69.2	4.7	
Overall Mean					4.5	

Competences

Majority of 61.5% at Scale 5 and 38.5% at Scale 4 perceived that the extent of work on the project had contributed to the learning in the subject and/or studies they were taking. Table 3 shows the degree to which Service Learning project has contributed to developing the following transversal competences. In general, majority of the respondents perceived the experience had contributed a lot to their learning enhancing competencies as the aims of SULAM as almost all the questions scored above a mean of 4.5. Three questions pertaining to Communicating orally and in writing; expressing feelings and designing and managing projects scored a mean of 4.4, 4.2 and 4.4 respectively.

The degree to which Service Learning project has		03	Scale (%)		
contributed to developing the following transversal		Seale (70)			
competences:	2	2	4	5	Moon
1: not useful at all; 5: very useful	2	3	4	3	Mean
Familiarising yourself with and understanding ideas and	0.0	77	38.5	53.8	47
concepts Organizing and planning	0.0	,.,	50.5	55.0	,
Analysing and summarising	0.0	7.7	30.8	61.5	4.5
Taking decisions	0.0	7.7	38.5	53.8	4.7
Solving problems	0.0	7.7	30.8	61.5	4.5
Getting to know ICTs	0.0	7.7	38.5	53.8	4.7
Searching for and managing information	0.0	7.7	30.8	61.5	4.5
Communicating orally and in writing	7.7	7.7	23.1	61.5	4.4
Expressing feelings	7.7	7.7	46.2	38.5	4.2
Teamwork	0.0	7.7	7.7	84.6	4.8
Thinking critically	0.0	7.7	30.8	61.5	4.5
Developing ethical commitment	0.0	7.7	30.8	61.5	4.5
Recognising diversity and multiculturality	0.0	7.7	15.2	76.7	4.7
Negotiating	0.0	15.2	23.1	61.5	4.6
Adapting to new situations	0.0	7.7	23.1	69.2	4.6
Being creative and innovative	0.0	7.7	38.5	53.8	4.7
Working independently	0.0	7.7	30.8	61.5	4.5
Leading others	0.0	7.7	38.5	53.8	4.7
Showing initiative and entrepreneurial spirit	0.0	7.7	30.8	61.5	4.5
Being concerned with quality and improvement	0.0	7.7	38.5	53.8	4.7
Developing awareness of the social and environmental impact of actions	0.0	7.7	30.8	61.5	4.5
Designing and managing projects	7.7	7.7	23.1	61.5	4.4
Overall Mean					4.6

Table 3: The degree to which Servie	ce Learning project has con	ntributed to developing t	he following
	transversal competences		

Participation

The extent each of the reasons motivated the respondents to take part in the project is shown in Table 4. Majority indicated that the reasons that had motivated students to take part in the project had been very useful with a mean of 4.5. The lowest mean of 4.2 was obtained from work with an organization, association, etc.

Table 5 shows the degree of satisfaction of the students in the participation of the project. In general, the satisfaction level with an overall mean score of 4.5 indicated there were certain areas that had shortcomings. The lowest mean score of 4.3 was obtained from learning activities carried out. Three other areas with a mean score of 4.4 related to assessment made, schedules of activities and

participants with whom the respondents carry out activities. This indicated short of good planning and teamwork.

Extent each of these reasons motivated you to take part in	Scale (%)				
this project: 1: not useful at all; 5 very useful	2	3	4	5	Mean
Because I like this type of project	0.0	7.7	30.8	61.5	4.4
To work with an organization, association, etc.	0.0	15.2	30.8	53.8	4.2
To put course contents into practice	0.0	7.7	23.1	69.2	4.6
To help/work with others	0.0	7.7	23.1	69.2	4.6
To be a member of an organization, association, etc.	0.0	7.7	30.8	61.5	4.4
To contribute to a better society	0.0	15.2	15,2	69.2	4.5
Overall Mean					4.5

Table 4: Extent each of these reasons motivated students to take part in the project

Table 5: Degree of satisfaction in participation of the project						
Degree of satisfaction		Scale (%)				
(1 = not at all; 5 = a lot)	2	3	4	5	Mean	
How the project was set up	0.0	0.0	53.8	46.2	4.5	
The involvement of the school	0.0	7.7	38.5	53.8	4.5	
Own involvement	0.0	0.0	46.2	53.8	4.5	
Learning achieved	0.0	7.7	23.1	69.2	4.6	
Relationship between theory and practice	0.0	0.0	46.2	53.8	4.5	
Assessment made	0.0	7.7	46.2	46.2	4.4	
Learning activities carried out	0.0	15.2	38.5	46.2	4.3	
Resources available to carry out activities	0.0	7.7	38.5	53.8	4.5	
Schedule of activities	0.0	7.7	46.2	46.2	4.4	
Participants with whom you carry out activities	0.0	7.7	46.2	46.2	4.4	
Coordination between teachers and organization	0.0	7.7	30.8	61.5	4.5	
Lecturer's monitoring of work	0.0	7.7	23.1	69.2	4.6	
Service carried out	0.0	7.7	30.8	61.5	4.5	
Overall Mean		•	•	•	4.5	

Table 5: Degree of satisfaction in participation of the project

CONCLUSIONS

In the SULAM activities embedded in the Plantation Crop Mechanization can be summarised as having achieved the objectives in that the students were able to develop a deeper understanding of course materials and shown their ability to apply materials they learned in class to real problems. This led to an increased sense of connection to the complexity of social issues. They have attained leadership skills and greater self-knowledge. In the words of one student "*The community program at Gedong really makes our class bonding even stronger, we learn how to do our own role part and learn how to interact with students from SMK Gedong*".

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TEACHER-STUDENT INTERACTION USING PORTABLE VIDEO CONFERENCE TOOLKITS

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ABSTRACT

The problems of students engaging and participating less in online sessions are endorsed by educators, students, e-learning consultants/trainers at higher educational institutions, and institutional and national policymakers as mentioned in the literature review. Taking recognisance of the diverse classroom environment, the Erasmus+ KA220-HED - Cooperation partnerships in higher education involving 9 institutions from Europe and Asia formed the consortium to ideate Portable Video Conferencing Toolkits and Online Applications for Engaging Learning Experience Design in Higher Education Classroom (EdViCon). From a need analysis survey conducted, the components identified for a Portable Video Conference Toolkit (PVCT) include: (1) hardware, software, and training elements for videoconferencing, and (2) software & hardware for engaging students in learning activities. 10 modules are developed, and these modules are accessible online, powered by uQualioVideo4Learning.

Keywords: portable video toolkits, online learning, higher education

INTRODUCTION

Before the turn of the century, the education research was delving on the evolution of traditional faceto-face education towards digital education with the advancement of the technologies in developing 21st century students coming from the alpha, Y and Z generations (Chan, 2022). The 21st century students need learning traditionally school subjects with contemporary content themes to be combined with the 21st century skills (Trilling and Fadel, 2009). The growth of blended learning (BL) defined by Lewis and Parsad (2008) as a combination of online and in-class instruction with reduced in-class seat time for students is paced and technological, innovated with digital tools. Poon (2014) stated that BL is likely to be developed as the leading teaching approach for the future as one of the top ten educational trends to occur in the 21st century. Despite BL is rapidly changing the teaching and learning in higher education, Smith and Hill (2018) observed that it was not yet fully embedded and institutionalised in education either as an area of practice or a field of research.

Changes of teaching-learning practices during the Covid-19 Pandemic caused an acceleration of Elearning whether the teachers and students/learners are ready or not as Dhawan (2020) stated that crisis in fact paved the way for digital learning. Pokhrel and Chhetri (2021) indicated there is a pressing need to innovate and implement alternative educational and assessment strategies. During the transitioning of Covid-19 pandemic to endemic, it was recognised as a period of unfinished learning. Dorn et al. (2021) described the reality of students were going through unfinished learning without the opportunity during the adverse age of the Covid-19 to complete all the learning they would have in a typical year as they had disengaged from the education institution and slipped backward, losing knowledge or skills they once had. They reasoned that students moving on to the next grade unprepared having missed key building blocks of knowledge that were necessary for success which is not just academic knowledge, but social skills, behaviours, and mindsets to succeed in the learning environment or in the workforce.

The challenges of students engaging and participating less in online sessions are acknowledged by educators, students, e-learning consultants/trainers at higher education institutions, as well as institutional and national policymakers. In 2021, 9 institutions from Europe and Asia, formed a
consortium and obtained a grant from the Erasmus+ KA220-HED - Cooperation Partnerships in Higher Education to develop Portable Video Conferencing Toolkits (PVCT) and Online Applications for Engaging Learning Experience Design in Higher Education Classroom (EdViCon). The ideation of the portable video conference toolkits - (Hardware, software with video tutorial) and establishment of 2 joint Eurasian toolkits for Video Conferencing (One for hybrid (F2F+distance) and one distance) were carried out in recognition of the diversity of the classroom environment. In the ideation process, a study was conducted by Ling et al. (2024), aiming to capture the current practices and explore the issues of using video conferencing for teaching and learning in Malaysian higher educational institutions focusing on three target groups with hands-on experience: academicians, students, and elearning consultants or information technology (IT) support staff. Data gathered through focus group discussions and in-depth interviews employed the PACT framework identified a total of fifty-two (52) issues related to using video conferencing for teaching and learning. In the final process, the level of technological and pedagogical knowledge for adoption of portable video conferencing systems in hybrid teaching situations was determined to develop the PVCT and Online Applications for Engaging Learning.

METHODOLOGY

The survey instrument consisted of a set of questionnaires to determine the level of technological and pedagogical knowledge for adoption of portable video conferencing systems in hybrid teaching situations. There were two parts: Part A was on the competency relating to technical skills in using video conferencing application(s); usage of equipment / application related to video conferencing; competency level of using equipment / application(s) of video conferencing; and the needs of using added equipment to conduct video conferencing teaching. Part B was on pedagogical practices of video conferencing class. The data were gathered through google online platform from the Asian partners and France (translated to French) and analysed to identify the hardware and software components to ideate for training on video conferencing and the preferred solution to fill the gap in professional knowledge and skills to deliver the training.

RESULTS AND DISCUSSIONS

The 3 most used platforms to conduct video conferencing classes in the study are Google Meet, Zoom, and Microsoft Teams. The free version platform is preferred by the users. Among the five skills listed, the ranking of the skills is proficient in navigating platform functionality, proficient in quickly making the background change, proficient in technical set-up (i.e. connection/audio/video), proficient in eliminating distractions, and proficient in making breakout rooms for group activities and know how to move between rooms. The highest usage of equipment/application(s) related to video conferencing are Microsoft PowerPoint Microsoft Word, Computer / smart devices, and Microphone. The highest ranking in terms of competency level in using equipment/application(s) of video conferencing are Microsoft PowerPoint, Microsoft Word, computer / smart devices, microphone, and Microsoft Excel. The wireless headset which cuts down unnecessary background noise and provides clarity of audio during video conferencing has the most respondents perceived as "Indispensable". This is followed by the stylus pen/pen tablet which helps them to write, draw, or point with precision. Overall, respondents most agreed pedagogical approach practice is constructivist, followed by integrative, inquiry-based, collaborative and reflective approaches.

Ten modules were developed and are accessible online, powered by uQualioVideo4Learning. https://edvicon.uqualio.com/site/05e05854744f4a03a2411429a3ece2bb/channel-page/courses

Figure 1 shows the channel description for the 10 modules. The 10 modules are described in Table 1.



Portable Video Confering Toolkits for Hi...

The EdViCon Training Project

CHANNEL DESCRIPTION

The motivation for EdViCon was sparked by the experience with online teaching shared between students and education, who endorsed problems of engagement and participation due to technical issues, the absence of social norms, and the requirement for a higher level of motivation.

No one was prepared for the sudden shift from physical to online teaching during the COVID-19 pandemic. Nonetheless, we can derive from the experience that the facilitation of online teaching that enables the same interaction and engagement of a physical classroom requires a fundamental rethinking of how online teaching is designed.

Online and blended teaching must be designed to accommodate the different teaching and learning styles of educators and students alongside their preferences – whether they are mathematics students in a classroom, designers in a studio, or freshmen in a laboratory.

Figure 1: Channel decriptions of the Portable Video Conferencing Toolkits for higher education classroom

Module Code	Module	Description
Module 101	DTU's Two Portable Videoconferencing Toolkits Made by Technical University of Denmark (DTU)	In today's dynamic educational landscape, harnessing the power of video conferencing is essential for fostering remote learning and collaboration. This educational video explores the versatility and accessibility of portable video conferencing toolkits alongside online applications, revolutionizing the way we engage with learning environments. Delving into the myriad benefits and functionalities, viewers will discover how portable video conferencing toolkits provide educators and learners with the flexibility to connect seamlessly from any location. From interactive virtual classrooms to virtual field trips, these toolkits empower educators to create immersive learning experiences tailored to diverse educational needs.
Module 102	NTNU EdViCon Toolkits Made by Norwegian University of Science and Technology (NTNU) Norway	Educational Video Conferencing Systems in a Norwegian context. How to manage problems with sound and image.
Module 103	AMU EdViCon Toolkits Made by Aix-Marseille University (AMU) France	Presentation of two portable video conferencing toolkits and use of Miro board for collaborative activities, made in the context of the University of Aiz-Marseille.
Module 104	ANNU's Two Portable Videoconferencing Toolkits Made by An-Najah National University (ANNU) - In Arabic	Educational Video Conferencing Systems in a Palestinian context, including how to set up the systems.
Module 105	MFUTwo EdViCon Toolkits Made by Mae Fah Luang University (MFU), Thailand	Educational Video Conferencing Systems in a Thai context, including how to teach from home, and how to teach through hybrid classroom situations.
Module 106	UiTM's 2 Portable Videoconferencing Toolkits Made by Universiti of Teknologi Mara (UiTM) Malaysia	This course code is EdViCon 106, titled UiTM's Two Portable Videoconferencing Toolkits. The course comprises five topics: an introduction to online and hybrid classes, video conferencing toolkits, setting up a writing pad and stylus pen, an extended screen, an AI-powered webcam, and a Bluetooth wireless microphone with speakers. A short quiz at the end of each topic aims to test learners' understanding of the topic. Each module ends with a test.

Table 1. Ten modules accessible online, powered by uQualioVideo4Learning

Module 107	ULAB's Two Portable Videoconferencing Toolkits Made by University of Liberal Arts Bangladesh (ULAB) Bangladesh	In module 107 University of Liberal Arts Bangladesh presents the two portable Videoconferencing Toolkits recommended for the Bangladesh context.
Module 108	Online Tools for Engaging Students in Live Teaching Sessions Made by Teknologi Mara (UiTM) Malaysia	The course 'Online Tools for Engaging Students in Live Teaching Sessions' comprises 5 topics. The first topic introduces online tools for engaging students in live teaching sessions. This is followed by topics on using Kahoot, Mentimeter, Google Quiz, and Whiteboard to engage students in video conferencing classes. A short quiz at the end of each topic aims to test learners' understanding of the module. The course ends with a test.
Module 109	MFU Criteria for Tool Selection Made by Mae Fah Luang University (MFU) Thailand	Here's how to choose devices to extend hybrid classrooms at MFU
Module 110	Behavioural Change for Improved Video Conferencing Mediated Teaching Made by University of Liberal Arts Bangladesh (ULAB) Bangladesh	In this module 110, you will learn about behavioural Change for Improved Video Conferencing Mediated Teaching

https://edvicon.uqualio.com/site/05e05854744f4a03a2411429a3ece2bb/channel-page/courses

CONCLUSION

The EdViCon project is an international partnership on video conferencing and setting up a standard of excellence, innovation in higher education in using portable video conferencing and other online tools for engaging students. The level of technological and pedagogical knowledge for adoption of portable video conferencing systems in hybrid teaching situations provided the resources for the ideation of the portable video conference toolkits - (Hardware, software & video tutorial) and establish two joint Eurasian toolkits for VC (One for hybrid (F2F+distance) and one distance). The 10 modules were developed, acknowledging and defining the complexities and diversities of teaching styles and learning preferences that involve technological, social, behavioural, and other temporal factors responsible for video-conferencing mediated teaching. They form a part of training the educators, accessible through a free video e-learning platform and various dissemination channels including the website.

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