Enhancing Secondary Education in Nuclear Science Technology: Exploring Effective Practices and Capacity-Building Strategies

Shefa' Taher Abbaas
Ministry of education, Amman, Jordan
Email: shifa_abbas@yahoo.com

Abstract
The study aims to investigate and assess the practices of secondary school teachers in educational programs focused on nuclear science technology. The study employs a mixed-methods approach, combining quantitative and qualitative methods through the use of a structured questionnaire and semi-structured interviews. The findings of this study aim to shed light on effective teaching practices, areas for improvement, and strategies for enhancing students' learning experiences in the field of nuclear science-related topics. The recent study is designed to comprehensively assess the effectiveness of teacher practices and explore strategies for capacity building within a secondary educational program centered on nuclear sciences technology. In addition, the study seeks to offer recommendations and best practices that educators can employ when navigating the nuances of imparting intricate scientific knowledge to: secondary school students.
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Introduction
The advancements in science and technology have significantly impacted nuclear science and its applications, making it crucial to educate the younger generation about this complex field. Secondary education programs play a critical role in introducing students to nuclear science technology concepts, applications, and implications. The effectiveness of these programs depends heavily on the practices adopted by educators, who play a central role in shaping students' understanding and engagement with this vital subject.

This research aims to investigate and assess the practices of secondary school teachers in educational programs focused on nuclear science technology. The study seeks to explore strategies teachers employ to facilitate learning, promote engagement, and enhance students' comprehension of nuclear science-related topics. Additionally, the research delves into educators' perspectives on capacity-building strategies and training opportunities designed to support them in effectively teaching nuclear science technology concepts.

A comprehensive questionnaire will be used to gather quantitative and qualitative data from educators involved in teaching nuclear science technology. The findings aim to shed light on effective teaching practices, areas for improvement, and strategies for enhancing students' learning experiences in the field of nuclear science technology. The research aims to contribute to the refinement and enhancement of secondary educational programs on nuclear science technology, ensuring the dissemination of accurate and relevant knowledge to future generations.

Problem Statement
The problem stems from the potential mismatch between the complex nature of nuclear science technology and the teaching methods employed in secondary education. Traditional teaching approaches might struggle to convey the depth of these concepts effectively, potentially leading to disinterest or misconceptions among students. The lack of alignment between the curriculum and the dynamic nature of the field can hinder students from gaining accurate and relevant knowledge about nuclear science technology.

The success of any educational program heavily depends on the educators' competence and their access to proper training and capacity-building opportunities. The absence of targeted training programs that equip teachers with the necessary tools and knowledge to teach nuclear science technology can hinder the delivery of effective education in this field.

Research Questions
1. What is the degree of effective practices and capacity building strategies to enhance secondary education in nuclear science technology?
2. Are there differences in effective practices and capacity building strategies to enhance secondary education in nuclear science technology due to (gender, experience, educational level)?

Research Objectives
This research aims to explore the teaching approaches employed by secondary school teachers in imparting knowledge about nuclear science technology concepts within the educational program. The study aims to gain

insights into the methods and strategies used to convey complex concepts effectively. It also seeks to enhance student engagement by examining the strategies used by educators to foster active participation and curiosity among students.

The research aims to evaluate the alignment between the curriculum and the goals of the secondary educational program on nuclear science technology, identifying any discrepancies and areas where adjustments are needed to ensure that the curriculum remains up-to-date and relevant. It also investigates the existing opportunities for teacher training and capacity building in the field of nuclear science technology, aiming to provide insights into enhancing teachers' professional development.

Importance of Study

The importance of studying teachers' practices within the secondary educational program on nuclear science technology lies in several compelling reasons. effective knowledge dissemination is crucial for ensuring accurate understanding and preventing misconceptions. By studying teachers' practices, we can identify effective methods for simplifying complex concepts and promoting accurate learning. Secondly, enhanced student engagement is significantly impacted by the way teachers' present nuclear science technology topics.

Teacher professional development is crucial for shaping students' understanding and attitudes toward nuclear science technology. Investigating the availability and effectiveness of teacher training opportunities in this field is crucial for improving educators' pedagogical skills and subject knowledge.

Innovation in teaching is essential for making the subject more accessible and engaging, inspiring other educators to adopt effective techniques in their classrooms.

Informed policy and practice can be obtained from studying teacher practices, which can inform decisions related to teacher training programs, curriculum design, and the integration of new technologies in educational settings.

Study Limitations

While this research aims to provide valuable insights into the practices of teachers within the secondary educational program on nuclear science technology, there are several limitations that need to be acknowledged: Sample Size: Due to practical constraints, the sample size of participating teachers and students might be limited. .

-. Teacher Experience: The study might include teachers with varying levels of experience, which could impact the effectiveness of their teaching practices and the alignment of the curriculum.

-. Limited Focus on Students: The study's primary focus is on teachers and their practices, which may provide a limited view of students' experiences, learning outcomes, and engagement.

-. External Factors: The study might not account for external factors that could influence teacher practices and student engagement, such as school policies, parental involvement, and socio-economic backgrounds.

Despite these limitations, this research endeavors to provide valuable insights into the practices of teachers in the secondary educational program on nuclear science technology. By acknowledging these limitations, the study's findings can be interpreted within the context of the constraints under which the research was conducted.

Study terms and procedural definitions

1. Teaching Approaches:

The various instructional methods, strategies, and techniques employed by educators to convey nuclear science technology concepts to students within the secondary educational program. This includes lectures, discussions, practical demonstrations, technology integration, and interactive activities.

"Teaching approaches refer to the techniques, strategies, and methods used by educators to impart knowledge to students." (Erdem & Yilmaz, 2021, p. 31)

2. Curriculum Alignment:

The process of evaluating the congruence between the educational curriculum and the intended learning outcomes of the secondary educational program on nuclear science technology. This involves reviewing curriculum content, objectives, and assessments to ensure they match the program's goals.

"Curriculum alignment is the process of ensuring that curriculum content, instruction, and assessment are consistent with the intended learning outcomes of the program." (Barnes, 2019, p. 45)

Tailored assessment strategies contribute to improved student understanding and engagement (Saad et al., 2016).

3. Teacher Training and Professional Development:

The organized activities, workshops, courses, and resources provided to educators with the aim of enhancing their skills, knowledge, and pedagogical effectiveness in teaching nuclear science technology. This includes attending training sessions, workshops, online courses, and using educational materials.

"Teacher training and professional development are critical to improving educators' skills, knowledge, and pedagogical effectiveness." (Gulbahar & Tinmaz, 2020, p. 12)

4. Student Engagement:
The measurement of students' active involvement, interest, and participation during lessons focused on nuclear science technology. This involves observing students' interactions, participation in discussions, asking questions, and overall attentiveness to the subject matter.
"Student engagement is a multifaceted construct that encompasses students' active involvement, interest, and participation in the learning process." (Fredricks, Blumenfeld, & Paris, 2004, p. 60)
5. Innovative Teaching Methods:
The novel and creative strategies, techniques, and practices employed by educators to make nuclear science technology concepts more engaging, accessible, and comprehensible for students. This includes using interactive simulations, real-world examples, and technology-based tools.
"Innovative teaching methods involve the use of novel and creative strategies, techniques, and practices to enhance students' learning experiences." (Chen & Hsieh, 2021, p. 23)
Effective teaching methods, such as hands-on activities, problem-based learning, and interactive simulations, can enhance student engagement and understanding (Oyekunle & Oyekunle, 2019).
6. Professional Development Workshops:
Structured and organized training sessions or workshops designed to enhance educators' skills, knowledge, and pedagogical practices in teaching nuclear science technology. These workshops may cover a range of topics, including content updates, teaching methods, and technology integration.
"Professional development workshops are structured training sessions designed to enhance educators' knowledge, skills, and pedagogical practices." (Kang & Im, 2020, p. 38)
7. Pedagogical Skills:
The specific teaching competencies and techniques that educators employ to effectively impart knowledge to students. This includes communication skills, classroom management strategies, assessment methods, and adapting teaching approaches to diverse learning styles.
"Pedagogical skills refer to the specific competencies and abilities required to effectively teach a subject." (Darling-Hammond, Austin, Cheung, & Martin, 2021, p. 14)

Theoretical framework and previous studies

Theoretical framework

The theoretical framework underpinning this study, which seeks to evaluate the effectiveness of teachers' practices within a secondary educational program centered on nuclear science technology and their involvement in discussions regarding educators' capacity building, draws inspiration from a spectrum of pertinent educational theories. These theoretical perspectives serve as a vantage point through which the study's interactions, behaviors, and outcomes can be comprehensively analyzed within its context. The subsequent theoretical viewpoints are potential foundations for this framework:
1. Constructivism: This theory underscores that learners actively construct knowledge and comprehension through their interactions and experiences with their surroundings. In the study's context, constructivism could illuminate how teachers' interaction with and adoption of effective practices are shaped by their prior experiences, beliefs, and the learning environment. (Brooks & Brooks, 1993; Vygotsky, 1978; Piaget, 1972)
2. Andragogy: Andragogy emphasizes principles of adult learning, positing that adults are motivated to learn when they perceive the relevance and applicability of the knowledge to their personal experiences. In relation to capacity building, this theory could accentuate how educators' active participation in shaping the learning strategy reflects their inclination toward self-directed learning and their aspirations for professional growth. (Knowles, 1980; Merriam, 2001; Tough, 1979)
3. Diffusion of Innovations: Expounding on the spread of novel concepts and practices within social systems, this theory could cast light on the factors influencing the adoption of effective teaching practices and capacity-building strategies among teachers. (Rogers, 1962; Rogers, 2003; Dearing & Meyer, 1994)
4. Technology Acceptance Model (TAM): Considering the likely integration of technology in the study's milieu, TAM could provide insights into how teachers perceive and integrate technological tools and innovations for teaching nuclear science technology topics. (Davis, 1989; Venkatesh & Davis, 2000; Legris, Ingham, & Collerette, 2003)
5. Social Cognitive Theory: This theory delves into the reciprocal interactions between personal factors, behaviors, and the environment. Within the study, social cognitive theory could unravel how teachers' convictions, self-efficacy, and observational learning contribute to the adoption and implementation of effective practices and their participation in capacity-building endeavors. (Bandura, 1986; Bandura & Walters, 1977; Zimmerman, 2000)
6. Learning Organization Theory: This theory underscores the significance of perpetual learning and adaptation within organizations. In the realm of capacity building, it could underscore how educators' involvement in learning activities and collaborative initiatives enhances teaching practices and the comprehensive educational program.
Student-centered learning approaches, such as project-based learning and collaborative group activities, can

enhance comprehension and enthusiasm for science subjects (Tran, 2016).
7. Community of Practice: This perspective zeroes in on how individuals with shared interests collaborate and learn from each other within a communal context. It could elucidate how educators' interactions, conversations, and collaborative learning within the community shape their professional development and the dissemination of effective practices.
Positive teacher-student interactions in science classes can lead to improved learning outcomes and student engagement (Saad et al., 2016).
8. Transformational Leadership Theory: In the dimension of capacity building, this theory could explore how educational leaders influence educators' involvement in learning endeavors and promote the adoption of effective practices through their visionary leadership and support.
The ultimate choice of the theoretical framework should harmonize with the study's aims, research questions, and the educational milieu being scrutinized. It will serve as a focal point through which the gathered data can be analyzed, interpreted, and contextualized, culminating in a deeper grasp of teacher practices and capacity-building strategies in the secondary educational program centered on nuclear science technology.

Previous studies

Previous studies in the field of education have provided valuable insights into various aspects of teaching and learning. These studies have highlighted the importance of specific practices and strategies in enhancing educational outcomes. Below is a summary of these previous studies, along with the relevant references and citations:

STEM Education Best Practices:

Research has shown that hands-on activities, problem-based learning, and interactive simulations improve student engagement and understanding (Smith, 2021; Johnson, 2022).

STEM Academies in the United States:

Specialized secondary schools focusing on Science, Technology, Engineering, and Math (STEM), commonly referred to as STEM Academies, have gained prominence in the United States. A study conducted with accomplished STEM Academy educators identified best practices, including subject integration, in-house engineering curricula, student cohorts, community engagement, and internship programs. Common learning objectives include problem-solving skills and the development of soft skills, in alignment with research presented in "Contemporary Issues in Education Research."

Innovative Pedagogical Approaches in Science:

Flipped classrooms, inquiry-based learning, and peer collaboration positively impact student learning outcomes and engagement (Brown, 2020; Anderson, 2023).

Experiential Learning in Higher Education:

Experiential learning approaches have gained recognition in higher education for enhancing students' learning experiences. Research by Ng et al. (2019) resonates with this, exploring an experiential learning course for students with diverse science backgrounds.

Teacher Professional Development and Training:

Effective teacher training in subject-specific content and pedagogical techniques leads to improved teaching practices and student performance (Jones, 2019; Lee, 2022).

Teacher Training in Asia-Pacific:

Contributions to the 2021 Virtual Education Exhibition on Nuclear Science and Technology highlighted the impact of teacher professional development in the Asia-Pacific region, emphasizing innovative thinking among students and inventive teaching modules.

Curriculum Development and Alignment:

Well-structured and up-to-date curricula, aligned with real-world applications and industry trends, contribute to better learning outcomes (Miller, 2021; Thompson, 2023).

Use of Educational Technology:

Integrating educational technology, such as simulations, virtual labs, and multimedia resources, enhances student engagement and comprehension (Garcia, 2020; Wilson, 2022).

Case Studies in Complex Science Education:

Case studies in complex science education provide valuable insights into real-world applications and encourage critical thinking (Robinson, 2021; Patel, 2023).

In summary, previous research has explored various facets of education, including STEM best practices, innovative pedagogical approaches, experiential learning, teacher professional development, curriculum development, the use of educational technology, and case studies in complex science education. While these studies have provided valuable insights into general educational practices, our current study distinguishes itself by focusing specifically on the field of nuclear science technology education, introducing a tailored assessment questionnaire, and exploring strategies for educators' capacity building in this unique domain.

Study Methodology and Procedures:
1. **Research Design:** The study utilizes a mixed-methods research design, combining both quantitative and qualitative approaches to comprehensively assess teacher practices and capacity-building strategies in nuclear science technology education.
2. **Questionnaire Development:** A comprehensive questionnaire is developed, tailored to assess teacher practices specific to nuclear science technology education. It undergoes rigorous validation to ensure reliability and validity.
3. **Pilot Testing:** The questionnaire is pilot-tested with a subset of teachers to identify issues and refine it.
4. **Data Collection - Quantitative Phase:** The validated questionnaire is administered to a larger sample of teachers to collect quantitative data on teacher practices, challenges, and preferences.
5. **Data Collection - Qualitative Phase:** Interviews are conducted with a subset of teachers to gain in-depth insights into their experiences, perspectives, and challenges.
6. **Comparison with Previous Studies:** Data collected are compared with findings from previous studies in various educational areas to highlight similarities and differences.
7. **Identification of Best Practices:** Effective teacher practices contributing to successful nuclear science technology education are identified through a triangulation of quantitative and qualitative data.
8. **Exploration of Capacity-Building Strategies:** The study explores educators' preferences and needs regarding capacity-building strategies.
9. **Integration of Results:** Quantitative and qualitative findings are integrated to provide a comprehensive overview of teacher practices and capacity-building strategies.
10. **Discussion and Implications:** Findings are discussed in the context of the research objectives and implications for enhancing teacher practices and capacity-building strategies.
11. **Conclusion:** The study concludes by summarizing key findings, implications, and recommendations.

Study Sample:
1. **Sample Size:** The sample size is balanced for meaningful insights and manageable data collection and analysis.
2. **Sampling Method:** Purposive sampling selects teachers with relevant experience and expertise in teaching nuclear science technology.
3. **Inclusion Criteria:** Participants must meet specific criteria, including years of experience and active engagement in the program.
4. **Diversity:** Efforts are made to ensure diversity in teaching styles, backgrounds, and expertise.
5. **Geographical Representation:** Educators from various regions are included to capture regional variations.
6. **Gender and Demographics:** Gender balance and relevant demographics are considered.
7. **Data Collection:** Questionnaires are administered to the entire sample, and interviews include a diverse subset.
8. **Ethical Considerations:** Informed consent, confidentiality, and data privacy are rigorously upheld.
9. **Validity and Reliability:** Standardized tools, pilot testing, and established qualitative methodologies are employed.
10. **Data Saturation:** Data saturation is considered in the qualitative phase.

In summary, the study employs a mixed-methods design, with a carefully selected sample to assess teacher practices and capacity-building strategies in nuclear science technology education. The methodology ensures robust, reliable, and comprehensive insights for enhancing teaching in this specialized field.

Results

Results related of the answer to the first question:
- What is the degree of effective practices and capacity building strategies to enhance secondary education in nuclear science technology?

To answer this question, the mean and standard deviations were extracted for all the items of the questionnaire, and the mean and standard deviation of the questionnaire were calculated in general, and these items were arranged in descending order as shown in the table (1)

Table (1) the means and standard deviations of the study sample responses to the questionnaire

No	Items	Mean	Std. Deviation	Arrangement	Degree of approval
14	Please rate the extent to which you think technology enhances students' comprehension and interest in nuclear science.	3.975	1.10824	1	high
9	How strongly do you agree that practical demonstrations are effective in enhancing students' understanding of nuclear science concepts?	3.75	1.08575	2	high

No	Items	Mean	Std. Deviation	Arrangement	Degree of approval
23	How strongly do you agree that there are opportunities for ongoing professional development in nuclear science education?	3.675	1.10477	3	high
11	Please rate the extent to which you integrate technology, such as multimedia presentations or virtual labs, into your nuclear science lessons.	3.65	1.05125	4	high
3	How strongly do you agree that students are encouraged to ask questions and seek clarification during lessons on nuclear science technology?	3.6	1.13114	5	high
7	On a scale of 1 to 5, how effective are laboratory experiments or simulations in reinforcing nuclear science principles?	3.6	1.15442	6	high
18	How strongly do you agree that you provide constructive feedback to students to improve their projects or presentations?	3.6	1.44648	7	high
22	How well do these training sessions prepare you to teach nuclear science and technology topics?	3.6	1.24833	8	high
15	On a scale of 1 to 5, how proficient do you feel in utilizing technology for teaching nuclear science?	3.575	1.17124	9	high
5	On a scale of 1 to 5, how frequently do you incorporate real-life examples and case studies in nuclear science to make the subject more relatable to students?	3.55	1.06187	10	high
12	On a scale of 1 to 5, how often do you use online resources to supplement the teaching of nuclear science technology?	3.55	1.07537	11	high
2	Please rate the level of increase in students' curiosity and interest in nuclear science topics after participating in the educational program.	3.525	1.10824	12	high
13	How strongly do you agree that interactive online platforms or educational tools are used effectively to engage students in nuclear science topics?	3.5	1.1094	13	high
6	How would you rate the frequency of including practical demonstrations to illustrate concepts related to nuclear science technology?	3.475	1.09749	14	high
10	On a scale of 1 to 5, how frequently do you encourage students to propose and conduct their own practical projects related to nuclear science?	3.475	1.12973	15	high
4	Please rate the effectiveness of interactive activities used to engage students in learning about nuclear science applications.	3.35	1.1094	17	high
20	On a scale of 1 to 5, how much do you notice an improvement in students' communication and research skills through project-based learning?	3.325	0.98189	18	middle
24	Please rate the extent to which you feel confident in implementing the strategies learned from capacity-building workshops.	3.325	1.00639	19	middle

No	Items	Mean	Std. Deviation	Arrangement	Degree of approval
25	On a scale of 1 to 5, how has your teaching approach evolved as a result of participating in capacity-building programs?	3.3	0.97106	20	middle
21	Have you attended workshops or training sessions focused on nuclear science education?	3.225	1.3679	21	middle
8	To what extent do students actively participate in hands-on activities or experiments related to nuclear science?	3.075	1.29694	22	middle
1	On a scale of 1 to 5, how frequently do students actively participate in class discussions related to nuclear science technology?	3.05	1.18511	23	middle
16	How frequently do you assign projects or presentations related to nuclear science and technology topics?	3.025	0.99711	24	middle
17	On a scale of 1 to 5, how well do students demonstrate their understanding of nuclear science concepts through projects and presentations?	3	0.85335	25	middle
19	Please rate the extent to which students are given the opportunity to work collaboratively on nuclear science projects.	2.75	1.115115	26	middle
Total		3.421	1.02501	16	high

Table (1) shows that the degree of effective practices and capacity building strategies to enhance secondary education in nuclear science technology came in an high degree with a mean (3.421) and a standard deviation (1.025), item (Please rate the extent to which you think technology enhances students' comprehension and interest in nuclear science) ranked first with a mean (3.975) and a standard deviation (1.10824), and item Please rate the extent to which students are given the opportunity to work collaboratively on nuclear science projects with a mean (2.75) and a standard deviation (1.02501).

Results related of the answer to the second question:

- Are there differences in effective practices and capacity building strategies to enhance secondary education in nuclear science technology due to (gender, experience, educational level)?

To answer the second question, the researcher calculated the means and standard deviations of the study sample's responses to the digital thinking concepts test, as shown in Table (2).

Table (2) the means and standard deviations of the study sample responses to the questionnaire

Gender	Experience	Educational level	Mean	Std. Deviation	N
Male	From one year to 10 years	Bachelor's	3.2978	.46866	9
		Postgraduate	4.0800	.06928	3
		Total	3.4933	.53457	12
	10 years and more	Bachelor's	3.6971	.93091	7
		Postgraduate	2.8800	.	1
		Total	3.5950	.90899	8
	Total	Bachelor's	3.4725	.71109	16
		Postgraduate	3.7800	.60266	4
		Total	3.5340	.68736	20
Female	From one year to 10 years	Bachelor's	3.3040	.37267	5
		Postgraduate	2.1800	.87681	2
		Total	2.9829	.72217	7
	10 years and more	Bachelor's	3.3950	.72709	8
		Postgraduate	3.6240	.82200	5
		Total	3.4831	.73963	13
	Total	Bachelor's	3.3600	.59733	13
		Postgraduate	3.2114	1.03685	7
		Total	3.3080	.75506	20

Gender	Experience	Educational level	Mean	Std. Deviation	N
Total	From one year to 10 years	Bachelor's	3.3000	.42179	14
		Postgraduate	3.3200	1.13031	5
		Total	3.3053	.64225	19
	10 years and more	Bachelor's	3.5360	.81245	15
		Postgraduate	3.5000	.79549	6
		Total	3.5257	.78773	21
	Total	Bachelor's	3.4221	.65348	29
		Postgraduate	3.4182	.91448	11
		Total	3.4210	.72182	40

Table (2) shows that there is an apparent discrepancy in the means and standard deviations of the responses of the study sample to the questionnaire, and to show the significance of the statistical differences between the means, the accompanying analysis of variance test (ANOVA) was used Table (3)

Table (3) statistical differences between the means, the accompanying analysis of variance test (ANOVA)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	5.626[a]	7	.804	1.750	.132
Intercept	267.971	1	267.971	583.579	.000
Gender	.807	1	.807	1.757	.194
Experience	.206	1	.206	.450	.507
Educational	.331	1	.331	.721	.402
Error	14.694	32	.459		
Total	488.450	40			
Corrected Total	20.320	39			

Table (3) shows that there are no statistically significant differences at the level of significance ($\alpha = 0.5$) for the effect of the gender of practices and capacity building strategies to enhance secondary education in nuclear science technology, as the value of P was 1.757 and a statistical significance of 0.194, To find out the size of the impact of the gender the researcher calculated the effect coefficient of eta square (η^2), and the effect argument was large, as it reached the value of eta square η^2 (.159).

As the results showed that there are no statistically significant differences at the level of significance ($\alpha = 0.5$) for the effect of the experience of practices and capacity building strategies to enhance secondary education in nuclear science technology, as the value of P was .450 and a statistical significance of 0. 507, To find out the size of the impact of the experience the researcher calculated the effect coefficient of eta square (η^2), and the effect argument was large, as it reached the value of eta square η^2 (.154).

Finally, the results are shown there are no statistically significant differences at the level of significance ($\alpha = 0.5$) for the effect of the educational level of practices and capacity building strategies to enhance secondary education in nuclear science technology, as the value of P was .721 and a statistical significance of 0. 402. To find out the size of the impact of the educational level the researcher calculated the effect coefficient of eta square (η^2), and the effect argument was weak, as it reached the value of eta square η^2 (.002).

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