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Developing a Teaching Unit Based on (STSE) and Its Effects on the Development of Decision-Making Skills and Ethical Thinking among Female College Students in Israel

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Abstract

The goal of this study was to assess how a training module on science, technology, society, and the environment (STSE) concepts affected college students' capacity for ethical reasoning and decision-making. 48 female students were divided equally into an experimental group that received STSE-based education and a control group that received regular instruction as part of a quasi-experimental design. A decision-making test and an ethical reasoning scale were used in pre- and post-intervention evaluations to gauge the effectiveness of the instructional intervention. The findings showed that the STSE technique significantly improved decision-making skills and ethical reasoning abilities, favoring the experimental group. Notably, a significant relationship between ethical reasoning and judgment was found. These findings underscore the significance of crafting instructional modules grounded in the STSE framework across diverse academic disciplines, offering potential benefits for holistic student skill development in various curricular contexts.

Keywords

STSE, Decision-Making, Ethical Thinking, Developing a Teaching Unit

1. Introduction

The blending of various frameworks and approaches has drawn a lot of interest in the field of education and pedagogical development. This study is concerned with scientific education, specifically the effects of adopting a teaching unit based on the principles of science, technology, society, and environment (STSE) on

students' capacity for ethical reasoning and decision-making. This study aims to address the changing landscape of educational practices by drawing on theoretical foundations such as humanistic psychology, integral humanism, and transformational leadership (Acevedo, 2018; Bashori, Yusup, & Khan, 2022).

The integration of multiple frameworks and approaches has garnered significant interest in the field of education and pedagogical improvement. The present research centers on scientific education (Jimoyiannis, 2010) and investigates the effects on students' ethical reasoning and decision-making skills by including a teaching unit based on the concepts of science, technology, society, and environment (STSE). Based on a solid theoretical base that includes integral humanism, humanistic psychology, and transformational leadership (Acevedo, 2018; Bashori, Yusup, & Khan, 2022), this study aims to address how educational practices are changing.

By situating itself within the broader framework of education systems and policy implementation, this study highlights the potential of STSE methodologies to alter the educational landscape (Enyiazu, 2022; Khan, Khan, & Gulana, 2022). In response to requests for effective scenario-based learning (Ribchester & Healey, 2019) and holistic skill development (Chowdhury, 2016; Panissal, 2017), this study attempts to explore the symbiotic relationship between ethical thinking and decision-making aptitude. The inquiry into educational practices and their implications is supported by the analysis of interconnectivity and ethical considerations within pedagogical linkages (Schwartz, 2023; Turnbull, Chugh, & Luck, 2020). By interacting with a range of theoretical frameworks and academic works, this initiative seeks to enhance the discussion on education, ethics, and cognitive development (Towne & Shavelson, 2002).

This study emphasizes the potential of STSE techniques to change the educational landscape by locating itself within the larger context of education systems and policy implementation (Enyiazu, 2022; Khan, Khan, & Gulana, 2022). This research aims to investigate the symbiotic relationship between ethical thinking and decision-making capability as an endeavor in line with the calls for effective scenario-based learning (Ribchester & Healey, 2019) and holistic skill development (Chowdhury, 2016; Panissal, 2017). The examination of interconnectivity and ethical considerations within pedagogical connections serves to support the investigation into educational practices and their ramifications (Schwartz, 2023; Turnbull, Chugh, & Luck, 2020). This project aims to advance the conversation on education, ethics, and cognitive development by engaging with a variety of theoretical frameworks and scholarly works.

2. Literature Review

A historically unprecedented scientific revolution has ushered in rapid and unbroken change in all domains of living nowadays (Mansor et al., 2021). The technological revolution, which has been accompanied by an enormous influx of information about many fields of knowledge, is the most significant of these

shifts. Advanced educational systems have been motivated by this to scrupulously adjust to the quick progress, deliberately designing strategies, different programs, and alternatives. These initiatives, which have a significant human and financial resource commitment, are all intended to raise the bar for the educational process (Williams, 2017).

Our contemporary era is marked by an unprecedented scientific revolution, ushering in swift and uninterrupted transformations across all spheres of existence (Mansor et al., 2021). Chief among these changes is the technological revolution, accompanied by an overwhelming influx of information across various aspects of knowledge. This has spurred advanced educational systems to diligently adapt to the swift progress, strategically devising plans, diverse programs, and alternatives. These efforts involve substantial financial and human resources, all aimed at elevating the standard of the educational process (Williams, 2017).

The present educational scene is characterized by an unheard-of scientific revolution that has ushered in rapid and unbroken change in all areas of existence (Mansor et al., 2021). The most significant of these developments is the technological revolution, which has been accompanied by an enormous influx of information on numerous fields of expertise. Advanced educational systems have been inspired by this to diligently adapt to the quick advancements, methodically putting together strategies, a variety of programs, and alternatives. These initiatives, which are all geared toward raising the caliber of the educational process, need significant financial and human resources (Williams, 2017).

The prevalence of unusual behavioral traits like egocentrism, hostility, envy, and resentment gives rise to this need. Understanding right from wrong and arriving at precise judgments on moral and value-based attitudes are all aspects of ethical thought. It is a feature of moral growth that centers on moral evaluations of things like occurrences or phenomena (Acevedo, 2018).

The ability to distinguish between good and wrong is demonstrated through ethical thought, which creates a framework of moral principles that serve as a guide for ethical behavior. It serves as a normative framework for what behaviors are acceptable and unacceptable, according to several academics. According to Sambala, Cooper, and Manderson (2020), ethical thinking is especially important for teenage moral development because it helps them appreciate the moral virtues that support reciprocal social trust.

The importance of ethical thinking is demonstrated by the substantial effects it has on a person's character growth, which empowers them to maximize their individual strength. A crucial aspect of both human and community existence, morality is intricately entwined with socialization and education processes. It explores human behavior and its positive or negative effects on daily life. The foundation of a stable and long-lasting society is morality (Bashori, Yusup, & Khan, 2022).

The ability to make decisions is intimately related to ethical reasoning, and these two concepts interact in a complex way on the cognitive, psychological,

and behavioral levels. To enable competent decision-making, this includes evaluating a wide range of options, acquiring in-depth information, and eventually choosing the best alternatives (Zhang, Zhang, & Wang, 2023).

Nowadays, ethical reasoning is seen as a crucial skill that must be developed. Ethical thinking and decision-making skills are linked by a sophisticated cognitive, psychological, and behavioral process. To promote wise decision-making, this entails considering a range of options, gathering a plethora of facts, and ultimately selecting the best options (Zhang, Zhang, & Wang, 2023). The key to improving education is choosing a teaching approach and educational resources that increase instructional effectiveness and align with ongoing scientific discoveries. In order to advance in all areas of education, educators are prone to looking for mechanisms that encourage growth and revitalize the necessary conditions. The prior requires integrating a variety of practical tactics that are essential for boosting learners' motivation, adding enjoyment and interest, and simultaneously improving their practical and cognitive abilities (Enyiazu, 2022).

The science, technology, society, and environment (STSE) approach represents a strong path for the advancement and modernization of education. It teaches students to be functionally oriented, addressing social issues and environmental concerns while preparing them to meet and overcome these obstacles (Krawec, 2014). This method makes it easier for pupils to find, comprehend, analyze, and evaluate the complex interactions between science, technology, society, and the environment by focusing on scientific and technological topics like energy and food (Khan, Khan, & Gulana, 2022). This fosters comprehension of these issues' causes, consequences, and the contribution of science and technology to their solution. Additionally, it explores the connections between science, technology, society, and the environment while fostering students' scientific knowledge, cognitive skills, and sense of social responsibility—all of which are essential for creating responsible citizens in a time of rapid change and intricate complexity (Turnbull, Chugh, & Luck, 2020).

The Science, Technology, Society, and Environment (STSE) approach is based on three fundamental pillars: the inherent qualities of science and technology, the complex relationships between science and technology, and the context-specific relationships between science and technology and the environment and society (Ortiz-Revilla, Adúriz-Bravo, & Greca, 2020). One of the four dimensions emphasized in science curricula, scientific and technological culture, is probably best actualized within this paradigm (Steffe & Ulrich, 2020). This strategy includes the following three key applications:

First and foremost, it entails presenting and clarifying a variety of subjects relevant to learners' current and future concerns (Nurtamara, Suranto, & Prasetyanti, 2020). The curriculum might be centered on these areas by placing these themes in personal, local, or global contexts.

Second, a connection is made between the topics covered in the current curriculum, the socially relevant subjects, and the STSE framework's inherent di-

mensions.

Thirdly, the STSE approach serves as a tool for activities in the classroom. It strongly emphasizes problem-solving techniques, develops critical thinking abilities, and fosters decision-making abilities—qualities that are in line with the goals pursued by initiatives aimed at improving and reforming scientific education (Lederman & Lederman, 2014).

3. Study Questions

With these motivations in mind, the study was designed to address specific research questions:

1) Does a statistically significant discrepancy, at a significance level ($\alpha = 0.05$), exist between the mean performance scores of the experimental group and the control group in terms of decision-making skills? This discrepancy is attributed to the teaching methodology employed, namely, the science, technology, society, and environment (STSE) approach versus the traditional approach.

2) Is there a statistically significant distinction, at a significance level ($\alpha = 0.05$), between the mean performance scores of the two experimental groups and the control group in terms of ethical thinking? This distinction is attributed to the choice of teaching methodology, either the STSE approach or the traditional approach.

3) Does a statistically significant correlation, at a significance level ($\alpha = 0.05$), exist between decision-making skills and ethical thinking?

4. Study Objectives

The study sought to achieve the following objectives:

1) To know the effect of applying the (STSE) approach on decision-making and ethical thinking skills.

2) Identify the correlation between the skills of decision-making and ethical thinking.

5. Significance of the Study

The importance of the work is structured along two axes: theoretical importance and applied importance. Theoretical considerations highlight the novelty of examining the STSE approach's aspects and the effects they have on moral and ethical decision-making. It offers a sound theoretical foundation and advances research into Arab communities while enhancing academic dialogue in the language. The study's practical importance derives from the establishment of an instrument for subsequent research, thorough findings for stakeholders, and a broader goal to reverberate throughout educational settings. In order to advance instructional methodologies in Arab contexts, the study aims to direct educational practices that will help administrators, educators, and professionals by encouraging students to develop their capacity for ethical reasoning and decision-making.

6. Conceptual and Procedural Definitions

The study focuses on the Science, Technology, Society, and Environment (STSE) approach, which highlights issues caused by scientific and technical developments that have an impact on society and the environment. The study focuses on the educational module "Fire" and "Diabetes," which was created for the science curriculum with the goal of fostering students' ethical thinking and decision-making abilities (Raj et al., 2022).

The ability to make decisions involves choosing the best options to accomplish objectives. Using standards like equity and compassion, the researcher evaluated students' responses to 15 issues, such as genetic engineering, euthanasia, and urban development. A decision-making test created specifically for this use was used in the assessment (Hammond et al., 2015).

Ethical thinking involves logical processes guiding individuals to make moral decisions aligned with society. The study evaluated College students' ethical deliberation using an adapted Ethical Thinking Test, derived from previous work by Baron. Results were quantified through a cumulative ethical reasoning score.

7. Methodology

The study focuses on the Science, Technology, Society, and Environment (STSE) approach, which introduces challenges arising from scientific and technological advancements impacting society and the environment. The research involves an instructional module, "Fire" and "Diabetes," designed for the science curriculum, aiming to enhance decision-making skills and ethical reasoning.

Decision-making skills involve selecting optimal solutions to achieve goals. The researcher assessed students' reactions to 15 topics, including genetic modification, euthanasia, and urban growth, using criteria like equity and compassion. The assessment utilized a decision-making test tailored for this purpose.

A research plan incorporating two different groups—one an experimental group and the other a control group—was developed to answer the second inquiry. These groups' learning approaches were specifically developed for them. While the control group was taught using traditional techniques, the experimental group received instruction based on the science, technology, society, and environment approach.

For the purpose of assessing the decision-making proficiencies within these groups, a pre-treatment evaluation was administered followed by a post-treatment evaluation. This experimental design structure was implemented to elucidate the potential impact of the diverse instructional approaches on enhancing decision-making skills across the three groups.

In order to address the second inquiry, a research design was devised involving two dissimilar groups, one being an experimental group and the other a control group. The instructional methodologies adopted for these groups were distinctly structured. The experimental group underwent instruction based on

the science, technology, society, and environment approach, while the control group followed conventional teaching methods.

7.1. Study Population and Sample

The research cohort comprised all female second-year students enrolled at Isreali Colleges for Arab Teachers Qualification. Among them, there were 60 students pursuing a teaching certificate specialized in primary-level science education within the Department of Curricula and Methods of Teaching Science for the academic year 2019-2020.

The research sample, constituting 48 female students, was selected from the entire study population using a straightforward random approach. This sample size represented 80% of the total study population. In a quasi-experimental design, the 48 female students were split equally into an experimental group that got instruction based on STSE and a control group that received standard training.

7.2. Tools

The construction of the decision-making skills test followed a comprehensive review of theoretical literature and previous studies (Chowdhury, 2016; Mettas, 2011; Wiles, 2014). The test was designed to assess ethical decision-making abilities, drawing on a selection of ethical dilemmas in biology. Each dilemma was accompanied by questions, including open-ended ones, to gauge students' decision-making levels based on ethical standards outlined in works like (Mertens, 2019; Steffe & Ulrich, 2020; Swanson, 2022). Criteria such as peace, charity, justice, benefit, honesty, sincerity, and privacy were established to guide the assessment. These criteria were derived from a thorough analysis of existing literature, ensuring that there were no definitive right or wrong answers, and the student's understanding of each criterion was clarified. The test consisted of fifteen cases spanning the dimensions of science, technology, society, and environment, aligned with previous studies (Altisent, Buil, & Delgado-Marroquin, 2012; Zhang, Zhang, & Wang, 2023).

According to earlier studies (Altisent, Buil, & Delgado-Marroquin, 2012; Zhang, Zhang, & Wang, 2023), society and the environment were in line. These cases covered a variety of subjects, including as cloning, euthanasia, and genetically engineered foods, and acted as an extensive testing ground for students' capacity for moral judgment.

7.3. Vality and Stability of the Study Tool

The decision-making evaluation was tested on a preliminary sample of 12 people to establish its validity and reliability. In the initial analyses, correlation coefficients were calculated to evaluate the association between case understanding and total test scores as well as the relationship between case comprehension and individual case performance. A group of 10 skilled assessors from the Academic College of Education in Israel, Sakhnin College for Teacher Education in Israel,

and Yarmouk University in Jordan evaluated the test's legitimacy and suitability in terms of content validity. Based on their comments, language constructions were modified. Applying it to a 12-person exploratory sample allowed us to address construct validity.

In order to demonstrate the comprehensive approach taken in validating the decision-making assessment, Pearson correlation coefficients were computed to show the relationship between case comprehension and the overall test score (R1) as well as the correlation between case comprehension and the total test score (corrected item-total correlation, R2) (Table 1).

The study revealed correlation coefficients (0.685 to 0.837) between issue extent and decision-making test scores, all significant at $P < 0.01$, meeting Enyiazu's (2022) threshold of 0.35. Adjusted coefficients (0.519 to 0.730), exceeding Hahnel, Jung, and Goldhammer's (2023) 0.30 benchmark, reflected uniform student performance across test items, indicating strong construct validity (Kribbs & Rogowsky, 2016).

To enhance the decision-making test, a model was devised based on theoretical literature and sources like the Association of American Colleges and Universities

Table 1. Correlation coefficients between the degree on the case and the total degree of the test (R1), and the corrected correlation coefficient between the degree on the case and the total degree of the test (R2) for the decision-making test.

Issue	R1	R2
First	0.822**	0.7
Second	0.837**	0.73
Third	0.783**	0.64
Fourth	0.755**	0.61
Fifth	0.742**	0.62
Sixth	0.804**	0.71
Seventh	0.802**	0.71
Eighth	0.755**	0.64
Ninth	0.815**	0.73
tenth	0.779**	0.66
eleventh	0.685**	0.52
Twelfth	0.755**	0.63
Thirteenth	0.780**	0.67
Fourteenth	0.764**	0.64
Fifteenth	0.710**	0.56
First	0.822**	0.7
Second	0.837**	0.73

**Statistically significant at ($P < 0.01$).

website. A Rubric rating scale (Table 2) was formulated to address ethical considerations gathered from respondents and researcher input.

7.4. The Test of Ethical Thinking

The ethical reasoning exam, which is based on Kohlberg's theory (Baron, 2023), uses hypothetical moral quandaries to assess how closely participants' moral judgements adhere to moral standards. The test ensures systematic responses with a multiple-choice style and six responses that correspond to Kohlberg's stages. Construct validity was demonstrated by determining Pearson correlation coefficients for the circumstance and overall test degree (R1) and adjusted correlation coefficients (R2), while content validity was proven through the review of experienced arbitrators. This meticulous method guarantees the test's validity and reliability, hence confirming its relevance for the study's objectives (Ribchester & Healey, 2019).

The correlation coefficients, which ranged from (0.699) to (0.806), were statistically significant at the ($P < .01$) level, exceeding Enyiazu's (2022) criterion of (0.35), as shown in Table 3. Affirming construct validity in line with Ortiz-Revilla, Adúriz-Bravo, and Greca (2020), the corrected correlation coefficients, which ranged from (0.563) to (0.736), also above the standard of (0.30) set by Hahnel, Jung, and Goldhammer (2023), demonstrating similar performance patterns throughout test segments.

7.4.1. Correction of the Test of Ethical Thinking

The correction test shown in Table 4 was adopted according to the order of thinking stages by Kohlberg regarding the options that the study sample was asked to answer.

7.4.2. Stability of Moral Decision-Making and Thinking Tests

The decision-making and ethical reasoning tasks were administered and re-administered to a sample of (12) persons from outside the study population

Table 2. A rubric rating scale for designing the decision-making test.

Clause	Low degree (two marks)	Medium degree (four marks)	High degree (six marks)
The ability to analyze the situation	The student was not aware of potential ethical issues.	The student appears aware of some ethical issues but cannot analyze them properly.	The student understands the critical ethical issues and applies the standards learned in her Analysis.
Determining the parties to the situation	The student is unable to determine the parties to the situation.	The student identifies the parties to the situation but does not use them in dealing with it.	The student identifies the parties to the situation and thinks entirely from their perspectives.
Determining alternatives and expected results	The student did not use the ethical standards she learned to identify alternatives and outcomes.	The alternatives for the student are centered around one of the ethical standards she has learned.	The student offers multiple alternatives, employing multiple ethical standards.
Making decision	The student shows difficulty in determining the appropriate decision.	The student decides without relying on a specific ethical standard.	The student makes the decision based on the ethical standards she learned.

Table 3. Correlation coefficients between the degree of the situation and the total degree of the test (R1), and the coefficient and the corrected correlation between the degree on the situation and the total degree of the test (Corrected item-total correlation) (R2), for the test of ethical thinking.

Issue	R1	R2
First	0.737**	0.56
Second	0.751**	0.58
Third	0.806**	0.74
Fourth	0.796**	0.71
Fifth	0.699**	0.69

**Statistically significant at the level of ($P < 0.01$).

Table 4. Correction test of ethical thinking test.

First situation								
Question No.	Answer No.	Degree	Question No.	Answer No.	Degree	Question No.	Answer No.	Degree
First question	A	5	Third question	A	2	Fifth question	A	5
	B	1		B	4		B	2
	C	4		C	1		C	1
	D	2		D	6		D	3
	E	6		E	3		E	4
	F	3		F	5		F	6
Second question	A	2	Fourth question	A	2			
	B	1		B	6			
	C	3		C	5			
	D	4		D	1			
	E	5		E	4			
	F	6		F	3			
Second situation								
Question No.	Answer No.	Degree	Question No.	Answer No.	Degree	Question No.	Answer No.	Degree
First question	A	5	Fourth question	A	5	Seventh question	A	4
	B	3		B	3		B	3
	C	1		C	2		C	2
	D	4		D	1		D	1
	E	2		E	4		E	6
	F	6		F	6		F	5
Second question	A	4	Fifth question	A	3	Eighth question	A	5
	B	1		B	4		B	1

Continued

	C	6		C	1		C	6
	D	2		D	6		D	2
	E	5		E	2		E	4
	F	3		F	5		F	3
Third question	A	3	Sixth question	A	4	ninth question	A	4
	B	1		B	5		B	2
	C	4		C	1		C	3
	D	2		D	6		D	1
	E	5		E	2		E	6
	F	6		F	3		F	5

Third situation

Question No.	Answer No.	Degree	Question No.	Answer No.	Degree	Question No.	Answer No.	Degree
First question	A	4	Second question	A	4	Third question	A	5
	B	5		B	1		B	6
	C	6		C	5		C	1
	D	1		D	6		D	3
	E	3		E	2		E	2
	F	2		F	3		F	4

Fourth situation

Question No.	Answer No.	Degree	Question No.	Answer No.	Degree	Question No.	Answer No.	Degree
First question	A	3	Second question	A	5			
	B	4		B	2			
	C	5		C	1			
	D	1		D	3			
	E	6		E	6			
	F	2		F	4			

Fifth situation

Question No.	Answer No.	Degree	Question No.	Answer No.	Degree	Question No.	Answer No.	Degree
First question	A	2	Second question	A	4			
	B	6		B	5			
	C	3		C	1			
	D	5		D	6			
	E	1		E	2			
	F	4		F	3			

Table 5. The coefficients of stability of internal consistency and stability factor for the tests of decision-making and ethical reasoning.

Test	Stability coefficient	Stability of Retest
Decision-making skills	0.79	0.78
Ethical thinking	0.81	0.82

in order to confirm their consistency. The stability coefficient of stability (test and retest) and the Cronbach alpha coefficient of internal consistency stability are shown in Table 5.

As demonstrated in Table 5, the decision-making test exhibits reliability indicated by a Cronbach's alpha coefficient of (0.79) and a retest stability coefficient of (0.78). Both coefficients surpass the established threshold of (0.70), highlighting the test's commendable reliability. Similarly, the Ethical Thinking Test demonstrates reliability with a Cronbach's Alpha Reliability Coefficient of (0.81) and a Retest Reliability Coefficient of (0.82), both exceeding the specified threshold of (0.70), confirming the test's credibility and dependable reliability.

7.5. The Educational Material

To fulfill the study's objectives, a comprehensive approach was adopted. The science curriculum for the elementary stage was meticulously examined to identify pertinent Biology and Ecology content, which formed the basis for developing a content unit. This unit, focusing on science, technology, society, and environment aspects, was then divided into two parts—"Fire" and "Diabetes." The control group was taught these parts through traditional methods, while the experimental group received instruction under the STSE approach. Clear objectives were set for each part, aiming to enhance understanding and ethical engagement. Teaching methods employed interactive techniques such as brainstorming, dialogue, and group work, facilitated through platforms like Zoom and Classroom due to the pandemic. To ensure the validity of the educational material, a panel of experienced referees from reputable institutions evaluated the unit's content and suitability. Adjustments to language formulations were made based on their expert feedback, affirming the unit's quality and relevance for the study's context.

7.6. Study Variables

The current study included the following variables:

1) Teaching approach: It has three categories: (science, technology, society and environment approach, and the traditional method).

2) Decision-making skill.

3) The skill of ethical thinking.

Three important factors are included in this study: the way that students are taught, their ability to make decisions, and their capacity for ethical thought. The teaching methodology can be divided into two categories: the traditional me-

thod, which is more teacher-centered and didactic, and the Science, Technology, Society, and Environment (STSE) approach, which emphasizes real-world contextual learning. While the skill of ethical reasoning entails evaluating events from a moral standpoint, decision-making competence relates to the capacity to understand situations and make well-informed choices. The goal of the study is to look into how these factors interact, especially by examining how various teaching philosophies affect students' capacity for moral reasoning and decision-making. Through exploring these facets, the study aims to offer perspectives on the more extensive influence of instructional strategies on learners' ethical and cognitive growth within the classroom.

8. Results

8.1. General Outcomes

This section highlights the research outcomes, focusing on the impact of an educational intervention rooted in the science, technology, society, and environment approach on students' decision-making skills and ethical thinking at Collegeal phase. The results are presented systematically in response to the guiding questions. The first question's findings indicate statistically significant differences between the experimental and control groups in decision-making skills, as revealed through mean scores and standard deviations (Table 6).

The data presented in Table 6 clearly demonstrates notable disparities in the mean performance scores between the two participant groups (experimental and control) categorized by the teaching methodology variable (science, technology, society, environment, and traditional). The group instructed through the science, technology, society, and environment approach exhibited superior average performance in decision-making skills compared to the control group (traditional method). To assess the statistical significance of these differences, while controlling for the impact of initial performance, an Analysis of Covariance (one-way ANCOVA) was conducted, as outlined in Table 7.

Table 6. The arithmetic averages and standard deviations of the prior and post-performance of the three groups in decision-making skills.

Teaching approach	Prior performance		Post-performance	
	Arithmetic average	standard deviation	Arithmetic average	standard deviation
Science, technology, society, and the environment	45.563	7.266	77.125	3.202
Traditional	43.188	9.16 7	53.313	8.987
Total	43.604	7.085	68.667	12.623

*Highest degree (90).

8.2. Further Analysis of the Variables

Table 7 indicates significant differences (α = 0.05) in the mean performance of the experimental and control groups' decision-making skills. An evaluation was performed to compare the mean performance of all three groups while considering initial skill differences, resulting in adjusted arithmetic mean performances (Table 8).

Table 8 shows that the experimental groups had better decision-making abilities. The science, technology, society, and environment approach significantly accounts for 76.7% of the variance in decision-making abilities, according to the ANCOVA study. The Bonferroni test in Table 9 confirms the teaching strategy's effectiveness by reiterating the significant differences in adjusted mean performance.

Table 7. The results of the accompanying one-way Analysis of variance (ANCOVA) to test the significance of differences in the performance of the three groups in decision-making skills after controlling the impact of prior performance.

Source of variance	Squares sum	Degrees of freedom	Squares average	Value F	Level of statistical significance	ETA square
The pretest	70.748	1	70.748	1.789	0.188	0.039
Teaching-approach	5730.939	2	2865.469	72.444	0	0.767
Error	1740.377	44	39.554			
Total	233814	48				
Adjusted total	70.748	47				

Table 8. The arithmetic averages and standard deviations of the performance of the three groups in decision-making skills before and after adjusting the prior differences.

Group	Before adjustment		After adjustment	
	Arithmetic Average	Standard deviation	Arithmetic Average	Standard error
Science, technology, society, and the environment	77.125	3.202	77.472	1.594
Traditional	53.313	8.987	53.239	1.573

Table 9. Bonferroni test results for Post-Hoc comparisons between the adjusted arithmetic means of the three groups in decision-making skills, according to the teaching approach.

Teaching approach	Adjusted arithmetic average	Problem-based learning	Traditional
Science, technology, society, and the environment	77.472	2.182	24.233*
Traditional	53.239	-----	---

*Statistically significant at the level of ($P < 0.05$).

8.3. Benferroni Test Results

Table 9 presents significant results from the Bonferroni test, indicating meaningful differences in adjusted mean performances among the three groups based on their teaching approaches. Particularly, the science, technology, society, and environment group significantly outperformed the traditional learning group in decision-making skills. However, no significant distinction was observed between the science, technology, society, and environment group and the science, technology group.

As for the second question, Table 10 outlines arithmetic mean scores and standard deviations of ethical thinking performance for the experimental and control groups, categorized by teaching approach (science, technology, society, environment, and traditional).

Table 10 reveals significant differences in the mean performances of the three groups—experimental and control—based on their educational orientations (science, technology, society, environment, traditional) regarding ethical thinking. Notably, the science, technology, society, and environment group outperformed the control group (traditional) in ethical thinking.

To rigorously assess these differences in post-performance ethical thinking while accounting for prior performance, the one-way analysis of covariance (ANCOVA) was utilized. The outcomes are detailed in Table 11, providing insights into the assessment of ethical thinking performance differences among the groups, considering the influence of prior performance.

Table 11, which compares the mean performance ratings of the three groups—both experimental and control—with regard to ethical thinking, reveals statistically significant differences (= 0.05). These variances highlight how important the observed variations in ethical thinking performance are. In response to these findings, a comparison was made while taking into account possible ethical reasoning discrepancies from earlier. For ethical thinking, the three groups' adjusted arithmetic means were computed. The findings are succinctly described in Table 12, which offers details on the two groups' recalibrated mean ethical reasoning performance scores and standard deviations, both before and after earlier discrepancies have been taken into consideration.

Table 10. The arithmetic averages and standard deviations of the prior and post-performance of the three groups in ethical thinking.

Teaching approach	Prior performance		Post-performance	
	Arithmetic average	Standard deviation	Arithmetic average	Standard deviation
Science, technology, society, and the environment	78.938	5.118	107.438	5.416
Traditional	72.75	3.804	84.563	3.916
Total	76.563	5.027	101.583	13.037

*Highest degree (126).

Table 11. Results of the (one-way ANCOVA) to test the significance of the differences in the performance of the three groups in ethical thinking after adjusting the effect of prior performance.

Variation source	Squares Sum.	Degrees of freedom	Squares average	F value	The level of statistical significance	ETA square
The pretest	8.545	1	8.545	0.47	0.497	0.011
Teaching-oriented	5457.934	2	2728.967	150.03	0	0.872
Error	800.33	44	18.189			
Total	503,308.000	48				
Adjusted total	7987.667	47				

Table 12. The arithmetic averages and standard deviations of the performance of the three groups in the skills of ethical thinking before and after adjusting the prior differences.

Group	Before adjustment		After adjustment	
	Arithmetic average	Standard deviation	Arithmetic average	Error
Science, technology, society, and the environment	107.438	5.416	107.678	1.123
Traditional	84.563	3.916	84.176	1.206

8.4. Tiple-Group Performance Analysis

Table 12 clearly demonstrates significant variations in the mean ethical reasoning performances of the three groups, with the experimental group performing significantly better. The educational program based on the science, technology, society, and environment approach, coupled with problem-based learning, considerably improves ethical thinking, with the one-way analysis of covariance (ANCOVA) confirming this. This program accounts for a major percentage (87.2%) of the variation.

The Bonferroni test for Post-Hoc comparisons was used to analyze the differences in mean ethical reasoning performance between the two groups while taking into account the teaching strategy variable (science, technology, society, environment, traditional learning). The adjusted arithmetic mean performance comparison is shown in Table 13 together with the findings of the Bonferroni test, which indicate the influence of teaching strategies on ethical reasoning.

Table 13 unmistakably highlights a significant discrepancy in ethical thinking mean performances between the science, technology, society, and environment group and the traditional learning group. This solidifies the impact of the science, technology, society, and environment approach on ethical thinking improvement.

Moreover, Table 14 showcases a Pearson correlation coefficient analysis, revealing a statistically significant correlation between decision-making skills and

Table 13. Results of the Bonferroni test for (Post-Hoc) comparisons between the adjusted arithmetic means of the three groups in ethical thinking, according to the teaching approach.

Teaching approach	Adjusted arithmetic average	Problem-based learning	Traditional
Science, technology, society and the environment	107.678	−5.217*	23.502*
Traditional	84.176	-----	---

*Statistically significant at the level of ($P = 0.05$).

Table 14. Pearson correlation coefficient between degrees on the decision-making test and degrees on the ethical thinking test.

Dependent variable	Pearson Correlation Coefficient	Statistical significance
Decision-making skills	0.813	0
Ethical thinking		0.01

ethical thinking, reinforcing the interconnection of these constructs.

It is noted from Table 14, that there is a positive statistically significant relationship between the degrees on the decision-making test and the degrees on the ethical thinking test; in other words, the degrees for decision-making skills increase with the increase in the degrees of ethical thinking.

9. Discussion

The study's findings demonstrate a strong positive impact of the STSE-based educational program when addressing the first research question, which aims to determine whether there are statistically significant differences in decision-making skills between the experimental group taught using the STSE approach and the control group taught using traditional methods. These results are consistent with the observations made by Chowdhury (2016) and Dwivedi et al. (2021), who highlight the critical role that cutting-edge instructional strategies have in improving students' cognitive abilities.

Given the demand for flexible learning environments, the STSE approach's emphasis on contextualized real-world problems and technology integration is in line with modern educational practices (Lederman & Lederman, 2014; Newman, 1994). The STSE approach's capacity to promote interdisciplinary thinking, motivate engagement with social concerns, and inspire holistic reasoning underpins its success in creating decision-making prowess.

Additionally, the STSE approach's effectiveness is related to its focus on genuine problem-solving and critical thinking, which is consistent with the findings of Nurtamara, Suranto, and Prasetyanti (2020) and Ortiz-Revilla, Adúriz-Bravo, and Greca (2020). The method's incorporation of ethical factors into the decision-making process is consistent with Wiles's (2014) and Zhang, Zhang,

and Wang's (2023) observations that ethical factors are crucial to decision-making. As a result, the STSE approach shows promise as a mechanism for developing decision-making abilities by encouraging cognitive flexibility, analytical proficiency, and ethical reflection.

Moving on to the second research question, which asks if there are statistically significant ethical thinking differences between the experimental and control groups, the study finds significant differences, with the experimental group exhibiting considerably improved ethical reasoning. This result is consistent with research by Mansor et al. (2021), which highlights the transformative potential of cutting-edge educational initiatives in developing ethical consciousness. The inclusion of ethical difficulties and concerns in the STSE approach, as emphasized by Intan (2021) and Kribbs and Rogowsky (2016), cultivates students' ethical sensitivity and motivates them to reflect on moral and societal issues. The ability of the STSE approach to foster open discussion, respect for differing viewpoints, and the development of a feeling of social responsibility is what makes it effective at increasing ethical thinking (Williams, 2017; Zhang, Zhang, & Wang, 2023).

The results support research by Chowdhury (2016) and Dwivedi et al. (2021) that emphasizes the connection between cognitive development and ethical reasoning when looking at the third study topic, which investigates the relationship between decision-making abilities and ethical thinking. The STSE approach's focus on critical thinking, discourse, and problem-solving is consistent with the findings of Ribchester and Healey (2019) and Steffe and Ulrich (2020), which contend that effective ethical decision-making is supported by cognitive competence. The study's findings highlight the symbiotic relationship between cognitive development and ethical discernment and underline that moral concerns form the basis of informed decisions (Chowdhury, 2016; Dwivedi et al., 2021). This supports Kohlberg's claim that moral judgments are influenced by cognitive development (Dwivedi et al., 2021) and emphasizes the importance of nurturing both components at the same time.

The discussion section that follows offers a thorough interpretation of the study's findings, revealing the profound influence that an educational program founded in the science, technology, society, and environment (STSE) approach had on the participants' acquisition of ethical reasoning and decision-making abilities. The discussion also aims to establish consistency and compatibility between these findings and the relevant field investigations, adding to the larger conversation on cutting-edge pedagogy.

The primary goal of the study is to determine whether there are statistically significant variations in decision-making abilities between the experimental group, which received exposure to the STSE-based educational program, and the control group, which received conventional instruction. The results clearly demonstrate the STSE approach's effectiveness in developing and improving decision-making abilities. These results are consistent with the work of Chowdhury (2016)

and Dwivedi et al. (2021), who argue that modern education must go beyond established bounds to provide students the cognitive abilities they need to function in complex, technologically advanced society.

The STSE approach's distinctive capacity to promote interdisciplinary connections is a key aspect in the enhancement of decision-making skills. The STSE approach's promotion of the alignment of scientific ideas and technological developments gives students the ability to make deep connections between many academic areas, improving their cognitive agility. This is consistent with Acevedo's (2018) observations, according to which the STSE approach equips students to understand the widespread effect of science and technology in their everyday lives. As a result, kids develop decision-making skills and a proactive mindset that is ready to take on real-world issues. They also learn to internalize social ideals.

In line with the findings of Nurtamara, Suranto, and Prasetyanti (2020) and Ortiz-Revilla, Adúriz-Bravo, and Greca (2020), the STSE approach incorporates real-world situations to help students develop their analytical and practical problem-solving skills. In line with the findings of Roden (2022). The method develops a well-rounded decision-making process based on ethical considerations by immersing students in settings that call for ethical reflection. According to Kribbs and Rogowsky's (2016) views, the approach's emphasis on holistic reasoning and diverse problem analysis strengthens students' analytical skills and gives them the cognitive tools necessary to make morally correct decisions.

The results of the second research question highlight stark differences in the experimental and control groups' ethical reasoning, with the former showing significantly better performance. This finding is consistent with Mansor et al.'s research from 2021, which emphasizes the transformative potential of cutting-edge educational initiatives in fostering ethical consciousness. According to Intan (2021) and Kribbs and Rogowsky (2016), the STSE approach's incorporation of real-world ethical conundrums forces students to engage profoundly with moral and societal issues, developing ethical sensitivity and a propensity for moral debate.

Additionally, the STSE approach fosters respectful evaluation of many viewpoints and encourages open discussion, which is consistent with Williams' (2017) and Zhang, Zhang, and Wang's (2023) views. As a result of the supportive learning environment, students are better able to consider the ethical implications of their actions. The ability of this strategy to promote discussion and the development of well-reasoned opinions is consistent with the discoveries of Zhang, Zhang, and Wang (2023), improving ethical reasoning.

The third study topic looks into the relationship between ethical reasoning and decision-making abilities and finds a strong one. In keeping with the findings of Chowdhury (2016) and Dwivedi et al. (2021), the STSE approach fosters students' ability for objective analysis and logical reasoning in conjunction with problem-based learning strategies. These teaching techniques cultivate character traits like openness, sharing of information, and adaptability in thinking, en-

couraging an intrinsic passion for discovery and problem-solving. According to Dwivedi et al.'s (2021) perspective, the deep thinking skills fostered by these tactics lay the way for the development of ethical reasoning skills.

Importantly, the process of making decisions is heavily influenced by ethical considerations. By fostering careful investigation of complex ethical issues, the STSE approach's incorporation of ethical components empowers students to make informed judgments. According to Dwivedi et al. (2021), the symbiotic relationship between cognitive development and ethical discernment is consistent with Kohlberg's thesis. This approach entails a thorough analysis of the thinking behind each decision and goes beyond simple confirmation or negation of a stance.

Importantly, ethical thinking plays an integral role in the decision-making process. The STSE approach's integration of ethical dimensions equips students to make well-informed decisions by encouraging thoughtful analysis of multifaceted ethical considerations. This symbiotic relationship between cognitive growth and ethical discernment resonates with Kohlberg's theory, as highlighted by Dwivedi et al. (2021). This process extends beyond mere affirmation or negation of a stance; it involves a comprehensive examination of the reasoning underlying each decision.

According to the study, the Science, Technology, Society, and Environment (STSE) approach significantly improves college students' capacity for ethical thinking and decision-making. When compared to the control group that received conventional teaching, the experimental group that was exposed to the STSE technique showed statistically significant improvements in their ability to make decisions. This is consistent with earlier studies that emphasize the value of creative teaching methods for improving cognitive capacities. Furthermore, the experimental group's ethical reasoning significantly improved as a result of the STSE approach, corroborating the revolutionary potential of contemporary educational endeavors in promoting ethical consciousness. The results highlight the symbiotic relationship between cognitive growth and ethical discernment, highlighting the robust relationship between decision-making skills and ethical thinking.

10. Conclusion

This study's extensive analysis of the impact of the science, technology, society, and environment (STSE) approach on college students' ability to reason ethically and make decisions reveals the revolutionary potential of this method. The STSE approach places a strong emphasis on interdisciplinary connections, practical problem-solving, and ethical sensitivity. This emphasis is in line with current research and equips students with the crucial cognitive skills they need to deal with the challenges of today. The relationship between ethical thinking and decision-making skills demonstrates the symbiotic relationship between two cognitive processes. This study encourages the use of cutting-edge educational tech-

niques like STSE, emphasizing its crucial role in producing responsible, socially conscious people capable of handling difficult ethical and technological conundrums.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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