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Effectiveness of innovator's disruptive-based socioscientific learning (Innova-DB2SL) to improve analytical thinking and entrepreneurial skills

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Abstract

The study evaluates the INNOVA-DB2SL model's efficacy in enhancing students' analytical and entrepreneurial thinking skills, addressing the modern world's need for critical thinking and creativity in science learning. The study uses a mixed methods approach, combining qualitative and quantitative data. It employs MANOVA for quantitative analysis and collects qualitative data from student and instructor perspectives. The effectiveness of the INNOVA-DB2SL model is tested using a pretest-posttest control group approach. The sample includes 99 Senior High Non-Boarding School students and 183 Senior High Boarding School students. The INNOVA-DB2SL model, which integrates Socioscientific Issues (SSI) and the Scientific Approach, significantly enhances analytical thinking skills, with an average score of 80.62. This surpasses the Scientific Approach, which scored the lowest, indicating its limitations in cultivating deep analytical thinking. The study also found variations in these skills across different schools, with women generally outperforming men in both analytical and entrepreneurial thinking skills. The SSI model had the highest average score, slightly surpassing INNOVA-DB2SL, and younger students, particularly 16-year-olds, exhibited stronger analytical and entrepreneurial thinking skills. These findings highlight the importance of selecting appropriate learning models for students' academic and professional success.

Keywords: Analytical thinking skills, Entrepreneurial thinking skills, Innova-DB2SL model, Scientific approach, Socioscientific issues (SSI).

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1. Introduction

Analytical thinking skills are part of higher-order thinking skills, including recall, analysis, comparison, inference, and evaluation. They involve understanding relationships, sorting and categorizing, understanding cause-and-effect relationships, and obtaining information from charts, graphs, diagrams, and maps [1]. Analytical thinking is part of critical thinking skills

[2], which involve assessing and testing knowledge about similarities and differences, ranking up and ranking down relationships, diagnosing errors, and applying principles [3]. These skills are essential in the 21st century, particularly in the Industry 4.0 sector, and are highly valued in the 21st century [4].

Analytical thinking skills involve analyzing information and drawing conclusions, while critical thinking skills involve interpretation, analysis, inference, evaluation, explanation, and self-regulation [3]. Innovative thinking involves presenting various answers, problem-solving, expressing flexible ideas, and developing original ideas, going beyond routine thinking patterns [5].

According to many authors, thinking talents may be divided into numerous stages. Quellmalz [5] highlights the relevance of memory abilities in recovering knowledge, whereas Krathwohl [6] emphasizes the necessity of analysis in assessing concepts. Marzano et al. [2] incorporated features of matching, classification, and mistake analysis into the critical thinking process. Meanwhile, Montaku et al. [7] established four stages of conceptual understanding: element analysis, relationship analysis, principle analysis, and organizing. Suyatman et al. [8] found that matching, categorizing, evaluating principles, and analyzing relationships are all important steps in the thinking process. Furthermore, Noris et al. [9] emphasized skills in analytical thinking such as analysis, organization, generalization, and evaluation.

Entrepreneur Thinking Skills are essential for organizing and managing services or manufacturing for profit, aiming to produce commercial products with innovative value [10]. Entrepreneurship education is a carefully planned process to achieve a comfortable and quality life. These skills include logical thinking, perspective, organization, responsibility, confidence, social mindedness, good communication, and problem-solving abilities [11]. Entrepreneurial talents are formed through social interaction, direct observation, and hands-on experience [12]. Science education can implement entrepreneurship education to address societal problems related to science and technology [11]. Benefits of entrepreneurship include not giving up easily, risk-taking, self-esteem, innovation, creativity, success, opportunity, and courage [13]. Entrepreneurial skills are associated with effective communication, social environment, teamwork, productivity, and self-confidence [14]. Science-based entrepreneurial learning involves applying science concepts to everyday life, designing and making products with economic value and environmental developments [15]. Integrating entrepreneurship in science learning provides an integrated, holistic understanding of the material, a deeper understanding of subject relationships, critical thinking, creativity, risk-taking, competitive spirit, opportunity identification and creation, social responsiveness, and character [16].

Entrepreneurial characteristics include motivation, innovation, risk-taking, emotional control, self-confidence, decision-making, and emotional intelligence. Entrepreneurial skills include risk-taking, creativity, risk-taking, and project management. Entrepreneur thinking skills, adopted from Deveci and Seikkula-Lein [11], include creative and innovative thinking. These skills are crucial for 21st-century learning and are essential for implementing and generating innovative ideas. These skills are essential for success in the competitive business environment. Curth [17] emphasizes the role of persuasion, strategic thinking, and negotiation in building critical skills, whereas Deveci and Seikkula-Lein [11] stress risk-taking, brainstorming, curiosity, self-confidence, and originality as vital components of entrepreneurial thinking. Atalay [12] builds on these ideas by identifying invention, creativity, project planning and management, and leadership as critical variables in developing problem-solving skills. Meanwhile, Noris et al. [9] emphasize the need for proper planning, strategic thinking, innovation, and communication in effective decision-making and leadership.

The INNOVA-DB2SL model focuses on developing analytical and entrepreneurial thinking skills in science learning, addressing socioscientific issues relevant to real-world challenges. The Innova-DB2SL model is a combination of the socioscientific issue (SSI) and scientific approach, aimed at empowering students' analytical thinking skills and entrepreneurship towards social issues. It consists of five syntaxes: Observation, Social-Reasoning, Experimenting, Conceptualizing, and Evaluation [18]. This model aims to help students analyze complex social problems in authentic community life. The Innova-DB2SL model is a flexible, interactive, and student-centered learning approach that promotes learning by doing. It aligns with Dewey's theory of fun learning, which provides meaning for cognitive development and helps learners remember longer [19-22]. The model consists of five stages, empowering students' analytical thinking skills and entrepreneurial thinking skills. The study aims to evaluate the effectiveness of the INNOVA-DB2SL model in enhancing students' analytical and entrepreneurial thinking skills, aligning with the modern world's demand for critical thinking and creativity in science learning.

2. Material and Methods

This sort of study employs a mixed-methods approach, combining qualitative and quantitative methods. The multivariate test (MANOVA) was used for quantitative analysis, while qualitative data were gathered via student and instructor perspectives on the usefulness of the Innova-DB2SL model.

The effectiveness was tested utilizing a pretest-posttest control group approach. This test is carried out in both the limited and large size phases. The pretest is utilized prior to treatment with the Innova-DB2SL Model, and the posttest is administered following learning with the DB2SL Model. Learning-based treatment employs a model built by researchers, known as the Innova-DB2SL model. The study design employs a pretest-posttest control group structure. The experimental design for this study is as follows:

Table 1.
Research Design: Pretest-Posttest Control Group.

Subject	Pretest	Treatment	Posttest
Experiment	O_1	X_1	O_2
Control A	O_3	X_2	O_4
Control B	O_5	X_3	O_6

Description:
O_1: Pretest Experimental Class
O_2: Posttes Experimental Class
O_3: Pretest Control Class Socioscientific Issue (SSI)
O_4: Posttest Control Class Socioscientific Issue (SSI)
O_5: Pretest Control Class Scientific Approach
O_6: Posttest Control Class Scientific Approach
X_1: Intervention With Innova-DB2SL Model
X_2 and X_3: Intervention with SSI Model and Scientific Approach

The frequency distribution of the research sample includes 99 Senior High Non-Boarding School (SHNBS) students, 99 Senior High Boarding School (SHBS A) students, and 84 SHBS B students.

Table 2.
Class Frequency Distribution.

Class	SHNBS		SHBS A		SHBS B	
	N	(%)	N	(%)	N	(%)
Innova-DB2SL	32	32.3	35	35.4	35	41.67
Socioscientific Issues (SSI)	37	37.4	30	30.3	17	20.24
Scientific Approach	30	30.3	34	34.3	32	38.10
Total	99	100	99	100	84	100

The study analyzed the effectiveness of four learning approaches in Senior High Non-Boarding Schools: Innova-DB2SL Model, Socioscientific Issues (SSI), and the Scientific Approach. The SSI approach had the most participants, while the Scientific Approach had the smallest. The study also compared the effectiveness of each model in improving learning outcomes. The results showed that 105 students received the Innova-DB2SL, 88 with SSI, and 102 with the Scientific Approach, serving as comparison or control classes.

Table 3.
Gender frequency distribution.

No.	Class	SHNBS		SHBS A		SHBS B	
		N	(%)	N	(%)	N	(%)
1	Male	32	32.3	64	64.6	17	20
2	Female	67	67.4	35	35.4	67	80
Total		99	100	99	100	84	100

The study involved 282 participants from three schools, including a non-boarding school and a boarding school. The gender distribution was predominantly female, with females comprising 41.4% of the participants. This distribution affects the analysis of research data, necessitating consideration of potential bias or gender differences in features.

Table 4.
Frequency Distribution by Age.

No.	Class	SHNBS		SHBS A		SHBS B	
		N	(%)	N	(%)	N	(%)
1	16 Years	3	3.0	2	2.0	2	2
2	17 Years	58	58.6	59	59.6	64	76
3	18 Years	38	38.4	37	37.4	18	21
4	19 Years	0	0	1	1.0	0	0
Total		99	100	99	100	84	100

The study involved 282 participants aged 17-18 years, with the majority being in their middle to late adolescence. This age distribution may affect their understanding and response to learning. The study examined the relationship between age and the efficiency of the applied learning model using the Innova-DB2SL Model in experimental and control classes.

The N-Gain Score value was used in this effectiveness test to measure how much students' analytical thinking and Entrepreneur Thinking Skills improved. The N-Gain Score criteria used to evaluate the efficacy of the Innova-DB2SL Model are as follows:

Table 5.
N-Gain Score Criteria.

Score (%)	Criteria
(g) > 0.7	High
0.3 < (g) < 0.3	Moderate
(g) < 0.3	Low

Source: (Hake, 1998)

3. Results

According to the findings of the descriptive MANOVA study, the INNOVA-DB2SL model has an advantage in increasing analytical thinking abilities, with an average value of 80.62, which is higher than SSI (79.81) and the Scientific Approach (68.03). This demonstrates that the INNOVA-DB2SL approach, based on Socioscientific Issues (SSI) and the Scientific strategy, is more effective at improving analytical thinking abilities than other models. In comparison, the Scientific Approach has the lowest average rating, indicating that it is not ideal for teaching students to think analytically and in depth. Overall, the three models assist in increasing analytical thinking skills, with an average of 76.80.

Table 6.
Descriptive Statistical Test Results for Manova.

Aspect	Class	Mean
Analytical Thinking Skills	Innova-DB2SL	80.62
	Socioscientific Issue (SSI)	79.81
	Scientific Approach	68.03
	Total	76.80
Entrepreneur Thinking Skills	Innova-DB2SL	77.79
	Socioscientific Issue (SSI)	79.04
	Scientific Approach	68.36
	Total	75.47

The SSI model scored highest in entrepreneurial thinking skills, slightly higher than INNOVA-DB2SL (77.79), while the Scientific Approach scored lowest (68.36). The scientific problem-based approach is more effective in developing entrepreneurial attitudes, as it allows students to study social issues and design solutions. INNOVA-DB2SL excels in analytical thinking, while SSI excels in entrepreneurial thinking, promoting a practical, discussion-based approach to social issues.

The descriptive analysis of the MANOVA test findings revealed disparities in analytical thinking skills and entrepreneurial thinking skills among the three schools being studied (SHNBS, SHBS A, and SHBS B).

Table 7.
Descriptive Test Results for Manova Statistics Based on Schools

Aspect	School	Mean	Std. Deviation
Analytical Thinking Skills	SHNBS	78.51	12.57783
	SHBS A	73.94	12.25914
	SHBS B	78.10	9.93791
	Total	76.80	11.90845
Entrepreneur Thinking Skills	SHNBS	77.58	11.98517
	SHBS A	71.80	12.23967
	SHBS B	77.25	11.41202
	Total	75.47	12.18822

The study found that SHNBS and SHBS A have higher mean scores in analytical and entrepreneurial thinking skills than SHBS B. The overall mean for analytical thinking skills is 76.80, showing an excellent degree of proficiency. However, the significant standard deviation across all institutions indicates that these talents vary among kids. This might be due to variances in learning techniques, surroundings, or other variables that affect their growth.

The Manova Test's descriptive analysis by gender reveals variations in analytical thinking skills and entrepreneurial thinking skills between men and women.

Table 8.
Results Descriptive MANOVA Statistical Test Based on Gender.

Aspect	Gender	Mean	Std. Deviation
Analytical Thinking Skills	Male	73.66	11.87706
	Female	78.87	11.48466
	Total	76.80	11.90845
Entrepreneur Thinking Skills	Male	74.85	11.17387
	Female	75.88	12.81233
	Total	75.47	12.18822

The study found that women generally have better analytical and entrepreneurial thinking skills than men. Women scored 78.87, and males scored 73.66. The total average was 76.80, showing a rather high level of analytical thinking. Women demonstrated somewhat stronger entrepreneurial thinking skills, but with a larger standard deviation. This shows that women have stronger analytical and entrepreneurial thinking skills than males, possibly due to differences in learning styles or problem-solving techniques.

The findings of a descriptive analysis based on age demonstrate differences in Analytical Thinking Skills and Entrepreneurial Thinking Skills between the ages of 16 and 19.

Table 9.
Manova Statistics: Descriptive Test Results by Age.

Aspect	Age	Mean	Std. Deviation
Analytical Thinking Skills	16 Years	79.12	14.1969
	17 Years	76.48	11.80185
	18 Years	77.25	11.97834
	19 Years	72.92	8.83883
	Total	76.80	11.90845
Entrepreneur Thinking Skills	16 Years	77.13	14.26535
	17 Years	75.37	11.89246
	18 Years	75.56	12.67245
	19 Years	73.86	4.82247
	Total	75.47	12.18822

The study discovered that 16-year-old kids have stronger analytical and entrepreneurial thinking abilities than older students. The mean was 76.80, with a modest reduction as people became older. The study also discovered that 16-year-olds showed greater entrepreneurial thinking skills, with a larger standard deviation at age 16. This shows that younger children participate in more active learning activities and have stronger analytical abilities. However, the wide range of results implies that there are individual variances within each age group that should be investigated further.

The findings of the Multivariate Analysis (MANOVA) demonstrate that the Innova-DB2SL learning model has a substantial impact on Analytical Thinking Skills and Entrepreneur Thinking Skills.

Table 10.
Multivariate Test Results (MANOVA).

Learning Model Effect	Value	F	Hypothesis df	Error df	Sig.
Pillai's Trace	0.227	36.315	4	1132.000	.000
Wilks' Lambda	0.775	38.451b	4	1130.000	.000
Hotelling's Trace	0.288	40.594	4	1128.000	.000
Roy's Largest Root	0.278	78.577c	2	566.000	.000

The study found that the learning model significantly influences students' analytical and entrepreneurial thinking skills. Four statistical tests showed a significant difference in the influence of the model on these skills. Pillai's Trace showed that 22.7% of the variability in students' thinking skills is explained by the learning model. Wilks' Lambda and Hotelling's Trace showed significant differences in the model's effect on these skills. The study suggests that choosing the right learning approach is crucial for improving student competence and developing high-level thinking skills for future academic and professional success.

Table 11.
Results of the Inter-Subject Effect Test.

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Analytical Thinking Skills	17485.580[a]	2	8742.79	78.468	.000
	Entrepreneur Thinking Skills	11619.519[b]	2	5809.76	45.195	.000
Intercept	Analytical Thinking Skills	3200850	1	3200850	28728.06	.000
	Entrepreneur Thinking Skills	3109687	1	3109687	24190.8	.000
Class	Analytical Thinking Skills	17485.58	2	8742.79	78.468	.000
	Entrepreneur Thinking Skills	11619.519	2	5809.76	45.195	.000

The Innova-DB2SL learning model significantly impacts students' analytical and entrepreneurial thinking skills, as indicated by a Type III Sum of Squares of 17,485.58 and 11,619.52, respectively. The results of the multivariate test (MANOVA) indicate that different learning approaches impact students' skill achievement, emphasizing the importance of choosing the right model to improve students' thinking skills. This highlights the significance of selecting the right learning model.

Meanwhile, the N-Gain score analysis of each dimension of analytical thinking skills reveals that all dimensions have an average score greater than 0.7, indicating that the Innova-DB2SL Model is highly successful in enhancing analytical thinking abilities.

Table 12.
Shows the N-Gain score values for each dimension of analytical thinking skills.

Dimension	Sub-Dimensions	SHNBS		SHBS A		SHBS B	
		%	Description	%	Description	%	Description
Analysis	Identifying Phenomena	0.87	High	0.85	High	0.83	High
	Comparing facts	0.83	High	0.79	High	0.79	High
Organization	Categorize	0.82	High	0.80	High	0.77	High
Generalization	Concept generalization	0.87	High	0.81	High	0.79	High
	Coherence analysis	0.85	High	0.81	High	0.81	High
Evaluation	Providing Alternative Solutions	0.85	High	0.83	High	0.81	High

The Innova-DB2SL model intervention in three schools significantly improved students' analytical thinking skills in various dimensions. The Identifying Phenomena and Comparing Facts sub-dimensions saw a significant increase, indicating improved accuracy and systematic comparison of scientific phenomena. The Organization dimension saw a significant increase, particularly in Categorizing, indicating better organization of information. The Generalization dimension saw a significant increase in Concept Generalization and Coherence Analysis, indicating logical and deeper analysis of relationships between concepts. The Evaluation dimension saw a significant increase in Providing Alternative Solutions, indicating the ability to develop creative solutions based on a strong scientific understanding.

Table 13.
Presents the N-Gain Scores for entrepreneurial thinking skills across all dimensions and subdimensions.

Dimension	Sub-Dimensions	SHNBS		SHBS A		SHBS B	
		%	Description	%	Description	%	Description
Good Planning	Opportunity Analysis	0.87	High	0.72	High	0.85	High
	Potential Analysis	0.84	High	0.73	High	0.83	High
Strategic Thinking	Product Design	0.83	High	0.72	High	0.80	High
	Development Strategy	0.85	High	0.76	High	0.83	High
Creativity	Development Idea	0.83	High	0.73	High	0.81	High
	Product Innovation Design	0.85	High	0.77	High	0.83	High
Communication	Teamworking	0.86	High	0.74	High	0.83	High
	Networking	0.79	High	0.71	High	0.77	High
Leadership	Responsibility	0.82	High	0.73	High	0.79	High
	Coaching	0.77	High	0.76	High	0.82	High
	Final Product	0.87	High	0.71	High	0.70	Moderate

The Innova-DB2SL Model intervention in three schools showed a significant increase in entrepreneurial thinking skills. Students in Good Planning, Strategic Thinking, Creativity, Teamworking, and Leadership improved their ability to analyze opportunities and potential in the context of entrepreneurship. They also showed increased skills in product design, development strategy, and innovation. Communication skills, particularly teamwork and networking, also improved. Leadership skills, particularly responsibility and coaching, also improved. The final product sub-dimension showed an increase from 64.06% to 89.84%, indicating that students were able to produce quality final products based on their planning, strategy, creativity, communication, and leadership. Overall, the Innova-DB2SL Model intervention effectively equips students with entrepreneurial thinking skills to face future challenges in the business world and industry.

4. Discussion

The study analyzed the effectiveness of three models: INNOVA-DB2SL, SSI, and the Scientific Approach, in improving analytical thinking skills among students. The INNOVA-DB2SL model, based on Socioscientific Issues, was found to be more successful in developing analytical thinking skills than the SSI and Scientific Approach models. The study also found that females had higher mean scores in analytical thinking skills and entrepreneurial thinking skills. Additionally, the study found that the INNOVA-DB2SL learning model significantly influenced students' thinking skills, explaining 22.7% of the variability in their skills. The study suggests that selecting the right learning approach is crucial for improving students' competencies.

Learning through discovery encourages analytical thinking in students, utilizing science to understand morals, law, ethics, and socio-scientific issues. The Innova-DB2SL model enables students to consider cultural, environmental, economic, scientific, ethical, moral values, politics, and personal experiences in decision-making and moral reasoning [23-26]. This differentiated learning approach supports various student characteristics, such as talents, learning styles, and interests [16, 27-31]. Implementing this model requires diversifying content, methods, products, and learning environments [32].

The Innova-DB2SL model intervention in three schools significantly improved students' analytical thinking skills in various dimensions, including identifying phenomena, organizing information, generalizing concepts, and providing alternative solutions. It also improved entrepreneurial thinking skills, including effective planning, strategic thinking, creativity, teamwork, and leadership. Communication skills, teamwork, and leadership skills also improved. The final product sub-dimension showed an increase from 64.06% to 89.84%, indicating that students could produce quality final products based on their planning, strategy, creativity, communication, and leadership.

The observation stage in learning involves analyzing social phenomena and orienting problems based on real situations [33]. This process helps students understand real situations and conditions, and they are asked to explore and understand the phenomenon. The See Think Wonder (STW) approach helps students observe, think, and wonder about social issues, leading to predictions, conjectures, and hypotheses [34]. This method develops observation, critical thinking, and curiosity skills through three main stages: See, Think, and Wonder. In the See stage, participants observe the phenomenon, record changes, and reflect on their observations. In the Think stage, they reflect on the process, relate observations to existing knowledge, and ask follow-up questions [35]. Discovery-based learning enhances higher-order reasoning and thinking skills by focusing on the body's behavior in response to a stimulus. This method engages students actively and exercises cognitive skills to discover and solve problems through observation.

The Innova-DB2SL model is a tool for students to understand and apply social reasoning in the context of conventional and modern biotechnology. This model divides students' reasoning domain into personal, social conventional, and morality domains, allowing them to exchange arguments and improve adaptation. Conventional biotechnology, which uses living organisms or their components, has significant social and economic impacts, such as increasing income for local communities but also causing competition with large industrial products [36]. However, it is often considered more environmentally friendly due to its use of natural processes. The model also emphasizes the importance of ensuring equal access to benefits, protection of traditional knowledge, and government regulations to support the application of conventional biotechnology. Learning from experience involves incorporating reflective thinking skills, which involve five steps: sensing doubt, proposing hypotheses, conducting research, obtaining results, and using evidence to act. The model is supported by Albert Bandura's theory of social learning, which emphasizes learning through observation, modeling, and social interaction [37, 38].

The Experimenting stage is a crucial part of science learning, involving observations of social phenomena and the use of the experiment or practicum method to test hypotheses, collect data, and analyze results dunia [39]. This stage helps students understand concepts theoretically and develop practical skills such as designing experiments, operating tools, and recording data [40, 41]. Students can conduct experiments on functional food, cosmetics, and medicine, demonstrating their analytical and entrepreneurial thinking skills. The Innova-DB2SL model highlights the importance of the Experimenting stage in developing analytical and entrepreneurial thinking skills through scientific exploration and product innovation.

The conceptualizing stage involves students verifying data on social issues, analyzing concepts, and determining their impact. This stage is followed by the discussion and presentation method, where students present their findings in structured scientific arguments. This helps students develop a deep understanding of social issues, communication, and analytical thinking skills. The INNOVA-DB2SL model, aligned with Vygotsky's constructivism theory, uses the Zone of Proximal Development (ZPD) concept for problem orientation and group discussion, emphasizing the role of language in scientific thinking [42-44].

This evaluation stage not only trains students in making the right decisions but also develops communication and persuasion skills. The Innova-DB2SL syntax promotes learning by doing, allowing students to retain information for longer and making learning more engaging [45-47]. This approach aligns with Piaget's cognitive learning theory, which stresses assimilation, deficiency, and balance [19-22]. This paradigm is backed by epigenetic theory, which posits that changes in individual traits occur as a result of environmental influences in development patterns. Epigenetics, which includes DNA methylation, histone modification, and chromatin shape alterations, might influence pupils' knowledge and attitudes [48, 49]. The Innova-DB2SL paradigm is adaptable, interactive, and student-centered, allowing students to build their own knowledge without pressure. Fun learning adds significance to cognitive growth and allows kids to recall more.

Several factors impact student learning results while using the Innova-DB2SL paradigm. The implementation of the Innova-DB2SL paradigm focuses on experiment-based learning. Social relationships and encouragement have a substantial influence on pupils' analytical and entrepreneurial thinking skills [30, 50, 51]. Support and social engagement have a direct impact on analytical thinking skills, but not entrepreneurial thinking skills [52-54]. Social support and self-regulation help to improve cognitive capacities and identify elements for business success [55-57]. Health and physical exercise had no substantial impact on critical thinking and entrepreneurial thinking skills in either boarding or non-boarding schools [58-60]. Physical activity boosts self-regulation, which includes emotional management and interpersonal relationships [61, 62]. Motivation and attitudes are especially important in scientific education, as students' activities are initiated and sustained toward specified objectives [63-67].

INNOVA-DB2SL is a model that focuses on high-level thinking and experimentation, but it has several challenges in implementation. It takes longer than conventional methods, requires adequate support from resources and facilities, and requires high motivation and learning independence. The model also requires complex assessment rubrics for creativity and problem-solving. The success of INNOVA-DB2SL depends on teachers' readiness, students' cognitive development, and factors like parental education, economic conditions, and environment. Factors like parenting patterns, eating habits, social interactions, and learning methods also play a role.

5. Conclusion

The findings of the descriptive MANOVA study indicate that the INNOVA-DB2SL model effectively enhances analytical thinking skills, with an average score of 80.62, surpassing the Socioscientific Issues (SSI) model (79.81) and the Scientific Approach (68.03). This suggests that INNOVA-DB2SL, which integrates SSI and the Scientific Approach, is more effective in fostering analytical thinking than other methods. In contrast, the Scientific Approach scored the lowest, indicating its limitations in cultivating deep analytical thinking. The study also revealed variations in these skills across different schools, where SHNBS and SHBS A had higher mean scores compared to SHBS B. Furthermore, a gender-based analysis showed that women generally outperformed men in both analytical and entrepreneurial thinking skills, possibly due to differences in learning styles and problem-solving approaches.

The study further examined entrepreneurial thinking skills, showing that the SSI model had the highest average score (79.04), slightly surpassing INNOVA-DB2SL (77.79), while the Scientific Approach remained the lowest (68.36). This highlights the strength of SSI in encouraging students to engage in social discussions and design solutions, making it a more effective approach for entrepreneurial learning. Additionally, age-based analysis revealed that younger students, particularly 16-year-olds, exhibited stronger analytical and entrepreneurial thinking skills compared to older students. This trend suggests that younger learners engage more actively in learning activities, though individual differences within each age group require further exploration.

The results of the Multivariate Analysis (MANOVA) confirm that the INNOVA-DB2SL model significantly impacts both analytical and entrepreneurial thinking skills, as evidenced by the statistical significance across multiple tests. The N-Gain score analysis further demonstrates that the model effectively enhances various dimensions of analytical thinking, such as identifying phenomena, comparing facts, and providing alternative solutions, all of which achieved high improvement levels. Similarly, entrepreneurial thinking skills showed substantial development across dimensions like opportunity analysis, product design, teamwork, and leadership. These findings emphasize the importance of selecting appropriate learning models to optimize students' higher-order thinking skills, ensuring their preparedness for academic and professional success.

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