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Original Research Article

Scientific, inquiry, and animation integration: The IPSIA learning model in chemistry

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ABSTRACT

This study addresses the issue of low active participation among students in chemistry learning, as well as their difficulties in understanding macroscopic, microscopic, and symbolic concepts, which contribute to unsatisfactory learning outcomes. To tackle these challenges and enhance students' performance in chemistry, a valid, practical, and effective IPSIA learning model was developed. The research employed a development approach based on the ADDIE (Analyze, Design, Develop, Implement, and Evaluate) model, beginning with a thorough analysis of the curriculum. This was followed by the design of the IPSIA model, which was validated using a questionnaire instrument. The results of the validity test scored 98, categorizing it as "very good." Additionally, the practical test of the IPSIA model also received a score of 98, indicating that it is user-friendly. During the implementation phase, the effectiveness of the model was assessed through test results. The improvement in students' chemistry learning was evidenced by normalized gain scores: 0.57 for the control class and 0.72 for the experimental class at Senior High School (SMA) 2 Padangsidimpuan, as well as 0.52 for the control class and 0.64 for the experimental class at SMA 5 Padangsidimpuan. These findings demonstrate that the IPSIA learning model is valid, practical, and effective in improving students' chemistry learning outcomes.

Introduction

Chemistry, as part of the Natural Sciences, plays a crucial role in understanding various phenomena related to substances, including their composition, structure, properties, transformations, and dynamics. Chemistry education encompasses macroscopic, microscopic, and symbolic aspects, requiring skills and reasoning. Current education emphasizes a scientific approach at all levels, involving steps such as observing, questioning, experimenting, reasoning, and communicating. At the high school level, a key objective is to provide students with practical experiences in applying scientific methods through experiments. However, surveys indicate that chemistry teachers at Senior High School (SMA) in Padangsidimpuan rarely conduct practical activities, with many only doing 1-2 experiments per academic year. Current education emphasizes a scientific approach at all levels, involving steps such as observing, questioning, experimenting, reasoning, and communicating. At the high school level, a key objective is to provide students with practical experiences in applying scientific methods through experiments. However, surveys indicate that chemistry teachers at Senior High School (SMA) in Padangsidimpuan rarely conduct practical activities, with many only doing 1-2 experiments per academic year. This low frequency affects students' abilities to develop scientific attitudes, problem-solving skills, and conceptual understanding. Research shows that students often struggle with concepts and terminology, exacerbated by teachers' limited attention to students' conceptual understanding and pressures to cover syllabus content.

Recent studies reveal that integrating technology in chemistry education can significantly enhance students' conceptual understanding. Chen et al. (2021) found that molecular animation aids students in visualizing abstract concepts. Despite these findings, gaps remain in integrating the scientific approach, guided inquiry models, and animation into a comprehensive educational framework.

This research aims to bridge these gaps by developing and testing the effectiveness of the Integrated Scientific Approach, Inquiry, and Animation (IPSIA) Learning Model for high school chemistry education (Fig-1). The uniqueness of this study lies in the integration of three key elements scientific approach, guided inquiry, and animation within a single learning model. Unlike previous studies that focused on one or two elements, this research seeks to create synergy among all three to enhance conceptual understanding, scientific process skills, and student motivation simultaneously.

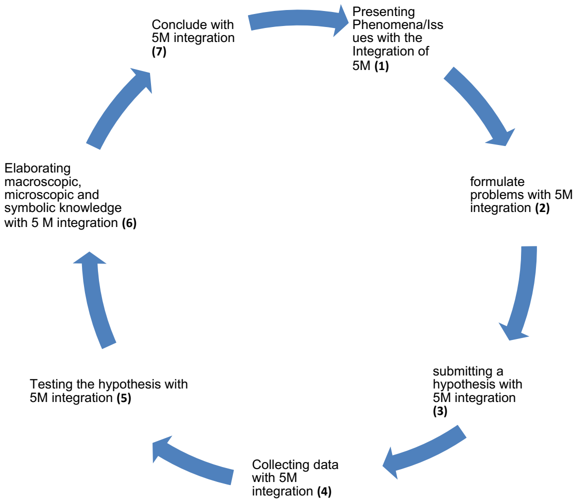

Fig-1. Syntax design of the IPSIA learning model (adapted from Zhan & Depaynos, 2023)

The integration of scientific approaches, inquiry, and animation in chemistry education is not just important; it is essential for fostering a generation of scientifically literate students capable of tackling 21st-century challenges. Research by Febriani et al. (2023) clearly demonstrates that inquiry-based learning models, which utilize real-world media, significantly enhance science literacy in early childhood. This early exposure lays a critical foundation for lifelong scientific understanding. Similarly, a study by Samadun et al. (2023) shows that guided inquiry learning models substantially boost critical thinking skills among students, creating a marked difference between those who use this model and those who do not. Moreover, Purwandari et al. (2022) highlight the effectiveness of inquiry learning models in improving students' competencies in chemistry. These models not only foster critical thinking and problem-solving capabilities but also promote a deep, conceptual grasp of chemistry. Yet, despite these promising outcomes, there is an urgent need to further integrate scientific approaches, inquiry, and animation within inquiry learning frameworks. This integration will make the learning experience more interactive, contextually relevant, and aligned with the demands of the modern world. Research by Adauyah and Aznam (2024) emphasizes that merging guided inquiry models with innovative technology can transform the learning experience, unlocking students' potential to understand complex chemical concepts. Furthermore, Suryati et al. (2024) reveal that combining constructivist-based learning strategies with inquiry-based methods holds transformative potential for enhancing student engagement, critical thinking skills, and problem-solving abilities in chemistry education. In conclusion, it is imperative to develop a cohesive learning framework that blends scientific approaches, inquiry, and animation. This strategy is crucial for making chemistry education more relevant and engaging for today's learners while greatly enhancing their conceptual understanding. A visual representation of this integrated learning model will be provided shortly, underscoring the transformative power of these educational strategies.

The scientific approach, known as 5M (Observing, Questioning, Hypothesizing, Experimenting, and Analyzing), is a model of learning implemented in the 2013 curriculum. This student-centered approach aims to enhance critical thinking and analytical skills by allowing students to actively explore learning materials. Through the 5M activities, students engage in observing phenomena, formulating questions, proposing hypotheses, gathering data through various techniques, analyzing findings, and communicating their conclusions. This method not only fosters curiosity and independent learning but also creates a conducive and productive learning environment. Research indicates that implementing the scientific approach significantly improves students' ability to learn autonomously, as evidenced by their increased participation and motivation. The systematic nature of these activities encourages students to develop a deeper understanding of concepts rather than relying solely on rote memorization. Overall, the scientific approach promotes an engaging and meaningful learning experience that enhances students' knowledge acquisition and critical thinking capabilities.

This study aims to design, test, and evaluate the effectiveness of the IPSIA learning model in enhancing students' conceptual understanding of chemistry. Furthermore, it seeks to assess the model's validity, practicality, and overall effectiveness in improving learning outcomes and the quality of chemistry education in secondary schools. This revision enhances clarity and flow while maintaining the original meaning.

Methods

Sample and population

The population in this study consists of all high school students involved in chemistry learning at Senior High School (SMA) 2 and SMA 5 Padangsidimpuan for practicality and effectiveness testing. The sample includes students from these schools who completed questionnaires and participated in lessons using the developed model. Chemistry teachers were also involved to provide feedback on the model's practicality and effectiveness. The tested products include the model book, teacher's guide, and student book, while effectiveness is measured through tests administered to students in both experimental and control classes.

General procedure

The development of an effective learning model is a systematic process that begins with identifying potentials and issues within a specific educational context. According to Plomp (2013), a quality learning model must meet three main criteria: validity, practicality, and effectiveness. Validity refers to the model's alignment with current educational theories, practicality relates to the ease of implementing the model in real contexts, and effectiveness pertains to the model's ability to achieve desired learning outcomes.

To develop a model that meets these criteria, this study adopts the ADDIE development procedure (Analysis-Design-Develop-Implement-Evaluate). The ADDIE model, proven effective in various educational contexts, offers a systematic and flexible approach to model development (Branch, 2009). Each stage in the ADDIE model has specific focuses and outputs that can be tailored to the needs of the research. Based on the adaptation of the ADDIE model proposed by Hwang et al. (2020) and adjusted for this research context, the development procedure can be outlined in Table 1.

Table 1. ADDIE Development Procedure (adapted from Hwang et al. (2020), and adjusted to the context of the research)

No	Step	Activity
1.	Analysis	Curriculum, characteristics of high school students, and chemistry learning processes
2.	Design	Model book, teacher's guide, student book, and validation testing by experts to obtain validity
3.	Development	Development: Practicality testing at SMA 2 Padangsidimpuan and SMA 5 Padangsidimpuan involving teachers and students
4.	Implementation	Effectiveness testing conducted at SMA 2 Padangsidimpuan and SMA 5 Padangsidimpuan after the products have been declared valid and practical
5.	Evaluation	Results of Revisions at Each Stage

This development procedure allows for a systematic and iterative approach to creating a learning model. As noted by Kumar et al. (2019), each stage in the development process should involve formative evaluation and repeated revisions to ensure the quality of the model being developed. The analysis stage focuses on gaining a deep understanding of the learning context, including curriculum analysis and student characteristics, which are critical steps in developing an effective model.

The implementation and evaluation of the model are carried out in stages, starting with limited practicality testing before transitioning to broader effectiveness testing. This approach allows for model refinement based on feedback from real contexts before full-scale implementation is conducted. By adopting a tailored ADDIE development procedure and considering the criteria for effective learning models, this research aims to produce the IPSIA Learning Model that is not only innovative but also applicable and effective in enhancing the quality of chemistry education at the high school level.

Data analysis

Comprehensive data analysis is conducted to ensure the quality of the developed learning model (Cahyadi et al., 2021). This process includes three main aspects: The validity of the model is assessed through expert questionnaires using descriptive analysis, while its practicality is measured based on responses from teachers and students, employing a Likert scale ranging from 0 to 100 (Ramadhan et al., 2023).

The criteria for assessing the validity and practicality of the developed learning model are more clearly presented in Table 2.

Table 2. Criteria for validity and practicality (Ramadhan et al., 2023)

No	Value Interval	Interpretation
1.	81-100	Very Valid/Practical
2.	61-80	Valid/Practical
3.	41-60	Fairly Valid/Practical
4.	21-40	Less Valid/Practical
5.	0-20	Not Valid/Practical

Effectiveness analysis

Effectiveness is measured through the improvement in learning outcomes (affective, cognitive, psychomotor) using normalized gain (Yulando et al., 2022):

$$\text{Normalized gain} = \frac{(\text{Post test score} - \text{pretes core})}{(\text{Maximum score} - \text{pre tes score})}$$

(Meltzer, 2002)

Table 3: Classification of normalized gain

Normalized Gain (g)	Classification
$g \geq 0.70$	High
$0.30 \leq g < 0.70$	Medium
$G < 0.30$	Low

Table 4. Testing the impact of the treatment

No	Learning Outcomes	Test	Criteria
1.	The difference in student learning outcomes in the cognitive domain using the inquiry-based learning model enhanced by animation compared to the conventional model.	a. Independent t-test Criteria: significance < 0.05 b. Post-hoc Tukey test Criteria: significance < 0.05	a. Data must be normally distributed (One Sample Kolmogorov-Smirnov Test) Criteria: Sig (2-tailed) ≥ 0.05 (5%) b. Data must be homogeneous (Levene's Test) Criteria: significance (p) > 0.05
2.	The difference in psychomotor and affective learning outcomes with practical activities in each session is analyzed using the Friedman test.	Criteria: P ≠ 0.05	

The effectiveness of the learning model in improving student learning outcomes was analyzed using normalized gain calculations. Table 3 presents the classification criteria of normalized gain scores used to determine the level of improvement in student achievement. The results of the testing on the impact of the treatment applied to the developed learning model are presented in Table 4. This testing was conducted to examine the effect of implementing the learning model on students' learning outcomes.

Results and Discussion

Analysis stage

The research results using the ADDIE model at the analysis stage revealed several key issues in chemistry education, including inadequate teaching materials that do not support conceptual understanding, low student interest and engagement, and the need for improvements in teaching methods and assessment. These findings align with Wulandari et al. (2019) This study analyzes chemistry textbooks and finds that the context within the books should facilitate students' understanding of chemical concepts. A good textbook not only emphasizes definitions and factual knowledge but also illustrates how to connect various concepts so that students can apply their knowledge in real-life situations. The issue of low student interest is supported by Ferreira et al. (2019), who emphasize that "the use of technology and active learning methods in chemistry education can significantly enhance student motivation and involvement." The need for improved teaching methods and assessment is consistent with the views of Cooper and Stowe (2018), who assert that "formative assessment integrated with inquiry-based learning can enhance students' conceptual understanding in chemistry".

As a solution, the development of an inquiry-based learning model supported by animation is backed by research from Akben (2020), which found that "the use of animation in inquiry-based chemistry education can enhance students' conceptual understanding and critical thinking skills". The importance of evolving chemistry education is emphasized by Sjöström et al. (2020), who state, "Chemistry education needs to evolve to meet the demands of 21st-century students, focusing on more relevant and engaging learning experiences." Based on these findings and support from recent research, the development of the IPSIA model, which integrates inquiry-based learning and animation, is seen as a suitable step to enhance the quality of chemistry education, address the challenges of conceptual understanding, and increase student interest and engagement in contemporary chemistry education.

Design stage

The design stage in the ADDIE model is the second step aimed at developing an inquiry-based learning model enhanced by animation (IPSIA) to improve student learning outcomes in chemistry. This design includes the creation of the IPSIA model book, which consists of an introduction, an explanation of the model, and a conclusion. The main components of the model include syntax, social system, reaction principles, supporting system, and learning impact.

The IPSIA syntax, which consists of seven stages, was developed to address the weaknesses of previous models and is integrated with the 5M scientific approach, creating a more interactive learning experience. Teachers serve as facilitators, assisting students in formulating problems and analyzing data while encouraging collaboration. The supporting system includes teacher and student books that aid the learning process. Validation indicates that this model is effective for high school chemistry education, enhancing conceptual understanding through observation and the use of animation. The results of the validation for the design products, including the model book, teacher's book, and student book using IPSIA, can be seen in Table 5.

Table 5. Results of IPSIA product validation

Component	Product Validity		
	Model Book	Teacher's Book	Student's Book
Content Suitability	96	96	99
Language Suitability	100	100	96
Graphic Quality	100	100	96
Average	99	99	97
Average	Highly Valid	Highly Valid	Highly Valid

The validation results for the design of the inquiry-based learning model with a Scientific Approach Assisted by Animation (IPSIA) in high school chemistry education show a very high validity level for its three main components: the Model Book, Teacher's Book, and Student's Book. All three components received validation scores above 95% for content suitability, language, and graphic quality, which, according to the validation criteria, fall into the "Highly Valid" category (Fadillah et al., 2020). This result indicates that the IPSIA model has excellent potential for implementation in high school chemistry education.

The content suitability of the IPSIA products scored 96% for the Model Book and Teacher's Book, and 99% for the Student's Book, indicating a high degree of alignment with the needs of high school chemistry education. This aligns with findings from Suyatman et al. (2021), who emphasize the importance of relevant and contextual learning content in enhancing students' understanding of chemistry concepts. Furthermore, Eilks et al. (2021) assert that high-quality chemistry learning materials should reflect recent developments in the field and their relevance to everyday life.

The language suitability aspect of the IPSIA products also showed very satisfactory results, with perfect scores of 100% for the Model Book and Teacher's Book, and 96% for the Student's Book. These high scores indicate that the language used in the IPSIA products is very comprehensible and appropriate for high school students' cognitive levels. This finding is supported by Nisa et al. (2020), who state that using appropriate language in chemistry teaching materials can enhance students' interest and understanding of abstract concepts.

The graphic quality of the IPSIA products also received high praise, with scores of 100% for the Model Book and Teacher's Book, and 96% for the Student's Book. This indicates that the visual design and layout of the IPSIA products are very engaging and support the learning process. The importance of visual aspects in chemistry education shows that effective visual representations can help students understand complex chemical concepts and improve their knowledge retention. The integration of animation in the IPSIA model aligns with current trends in chemistry education.

The scientific approach integrated into the IPSIA model is also supported by recent literature. Cahyani et al. (2023) found that the scientific approach in chemistry education can enhance students' critical thinking skills and science literacy. This finding is bolstered by international studies conducted by Cetin-Dindar (2020), which show that the scientific approach can help students develop a deeper understanding of chemical concepts and improve their ability to apply that knowledge in different contexts. Overall, the very high validation results of the IPSIA learning model demonstrate its significant potential to enhance the quality of high school chemistry education. However, as suggested by Purnama et al. (2021), expert validation should be followed by field trials to ensure the model's effectiveness in real educational settings. Further research is also needed to measure the impact of implementing the IPSIA model on student learning outcomes, motivation, and higher-order thinking skills in the context of chemistry education.

Development stage

At this stage, the researcher developed the revised learning model based on expert suggestions and conducted a Focus Group Discussion (FGD) for further input. The results of the FGD recommended revising the wording for better comprehension, replacing the term "learning strategy" with "learning model" in the student book, and adding video simulations related to chemical concepts. The model syntax will be presented in a table in the teacher's book, and sources and learning theories will be included.

Performance assessment was improved, with an emphasis on teachers reinforcing their roles in helping students analyze and draw conclusions. Evaluation information should also be communicated to students, and the scientific approach with the 5M will be applied. After revising the product, it was tested on a limited scale at SMA 7 Padangsidimpuan, with results indicating a "very practical" category for the model book (98), teacher's book (98), and student book (97). Suggestions from teachers and students regarding the addition of example questions and appealing designs were noted, with the purpose of this limited test being to anticipate potential issues in product implementation. Complete data on the practicality of the books is presented in Table 6, with the aim of this limited test being to foresee any errors in product application.

Table 6. Results of the IPSIA product practicality test

Component	Product Practicality		
	Model Book	Teacher's Book	Student's Book
Ease of Use	97	98	97
Time Efficiency	96	97	97
Benefits	100	98	98
Average	98	98	97
	Very Practical	Very Practical	Very Practical

The practicality test results for the Inquiry Learning Model with a Scientific Approach Assisted by Animation (IPSIA) indicate a very high level of practicality for its three main components: Model Book, Teacher's Book, and Student's Book. This practicality test is an essential part of the development stage in the ADDIE model, aimed at assessing the ease of use, time efficiency, and benefits of the developed product before it is implemented on a larger scale (Sari et al., 2019).

The usability aspect received very high scores for all three IPSIA components (Model Book: 97%, Teacher's Book: 98%, Student's Book: 97%). These results indicate that the IPSIA product is easy for both teachers and students to use in the learning process. According to a study by Scherer et al. (2019) in "Computers & Education," usability is a crucial factor in the adoption of educational technology, as it can enhance motivation and effectiveness among end users. The high usability scores of IPSIA align with instructional design principles that emphasize the importance of a user-friendly interface in the development of technology-based teaching materials (Moreno-Guerrero et al., 2020).

Time efficiency also received very good ratings (Model Book: 96%, Teacher's Book: 97%, Student's Book: 97%). This indicates that the use of IPSIA products can optimize learning time. Time efficiency is an important aspect of learning model development, especially within the context of a dense curriculum. The benefit aspect received the highest scores among the three assessed aspects (Model Book: 100%, Teacher's Book: 98%, Student's Book: 98%). These very high scores indicate that users find the IPSIA product highly beneficial in supporting the chemistry learning process. According to the updated Technology Acceptance Model (TAM) by Scherer et al. (2019), perceived usefulness is a strong predictor of the adoption of educational technology. The high benefit score of IPSIA suggests a significant potential for acceptance and widespread implementation in chemistry education.

However, it is important to note that this practicality test is part of the development stage, and further evaluation is necessary during the implementation phase to ensure the effectiveness of IPSIA in improving student learning outcomes. As suggested by Trust and Parra (2019), both formative and summative evaluations should be conducted continuously to ensure the quality and impact of the developed educational product.

Implementation stage

The researchers conducted effectiveness testing of the developed product by measuring learning outcomes in the cognitive, psychomotor, and affective domains. A description of the cognitive domain learning outcomes data, obtained through testing at SMA 2 Padangsidimpuan and SMA 5 Padangsidimpuan, is presented in Fig-2.

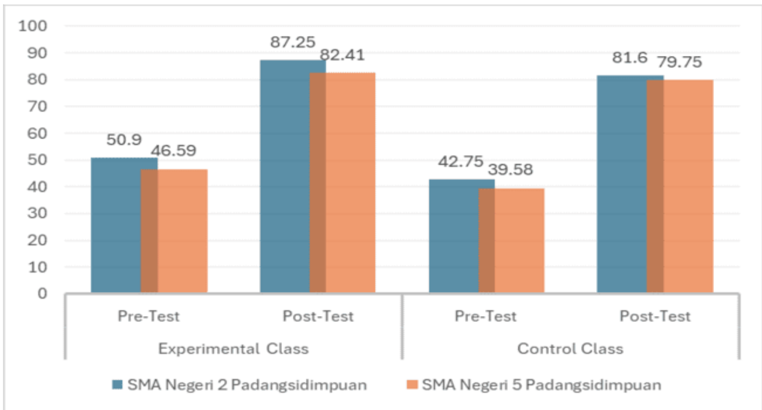

Fig-2. Cognitive domain learning outcomes

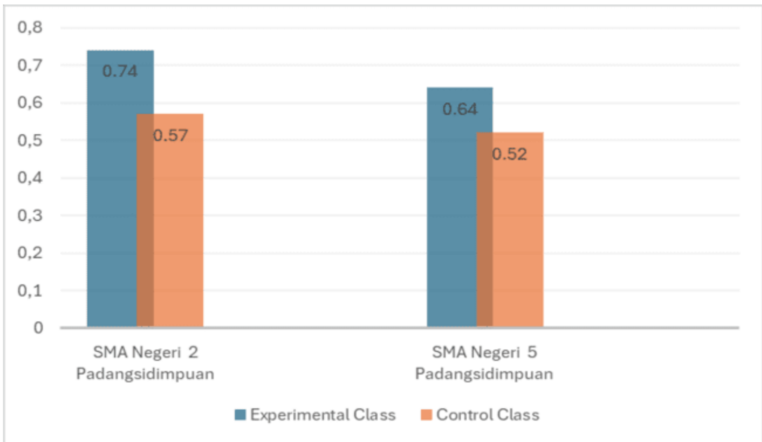

Fig-3. Gain in cognitive domain learning outcomes

Based on the analysis of the research results presented in Fig-2, there is a significant difference in chemistry learning outcomes between students in the experimental class, which utilized the IPSIA learning model, and those in the control class, which followed conventional learning methods. The data indicate that the average chemistry learning outcome in the experimental class was 87.25, compared to 81.6 in the control class. The results demonstrate that the experimental class achieved higher learning outcomes, suggesting that the implementation of the IPSIA learning model was effective in enhancing students' understanding of chemistry concepts. The IPSIA learning model integrates a scientific approach, inquiry, and animation into chemistry instruction, allowing students to actively engage in the learning process through systematic stages. This approach enables students to deepen their understanding of chemistry concepts by engaging in observation, investigation, and visualization through animation, making their learning experience more meaningful and effective.

The difference in the improvement of learning outcomes in the cognitive domain between the two schools can be seen by comparing the performance gains at SMA 2 Padangsidimpuan and SMA 5. This evaluation focuses on the enhancement of learning outcomes in the experimental class that used the IPSIA learning model, in contrast to the control class that applied conventional teaching methods, as illustrated in Fig-3.

The research findings presented in Fig-2 indicate that the normalized gain in chemistry learning outcomes for students in the experimental class, which utilized the IPSIA learning model, is significantly higher than that of the control class. At SMA 2 Padangsidimpuan, the difference was 17%, while at SMA 5 Padangsidimpuan, it was 12%. These results underscore the positive impact of the IPSIA model on student learning outcomes, attributed to several factors. First, the IPSIA model fosters active student participation, which enhances their understanding of chemistry concepts. Additionally, contextual learning enables students to relate lessons to real-life situations, thereby boosting their motivation and interest. Collaborative support through group work encourages students to assist one another and engage in meaningful discussions, reinforcing their comprehension. Furthermore, the model not only promotes content mastery but also develops critical and analytical thinking skills. In conclusion, the IPSIA learning model effectively enhances students' chemistry outcomes. Further research is needed to explore additional aspects and identify more effective teaching strategies in chemistry education.

To assess the effectiveness of the Inquiry Learning Model assisted by animation, a quasi-experimental design was employed using a Pretest-Posttest Control Group Design. The analysis utilized a t-test, which required prerequisite testing for normality and homogeneity. The homogeneity test, conducted using Levene's Test, determined whether the samples originated from homogeneous populations by comparing the variances between the two groups. The interpretation of homogeneity was based on the significance value (p): if $p > 0.05$, the data were considered to come from a homogeneous population, while if $p < 0.05$, the data were deemed to come from a non-homogeneous population.

The implementation of the Inquiry Learning Model with a Scientific Approach Assisted by Animation (IPSIA) shows positive results in enhancing student learning outcomes in the cognitive domain. These results align with the findings of Jiang et al. (2021), which state that the integration of technology in science education can significantly improve students' conceptual understanding. According to Fig-1, there is an observable increase in cognitive domain learning outcomes at both schools studied. This indicates the effectiveness of the IPSIA model in facilitating the learning process. These findings are consistent with the research of Zulkarnain et al. (2024), which found that technology-assisted inquiry approaches can enhance students' cognitive learning outcomes in science subjects.

Fig-2 shows the difference in gain between the experimental class using the IPSIA model and the control class using the conventional model. The higher gain in the experimental class indicates the superiority of the IPSIA model in enhancing students' cognitive learning outcomes. This finding supports the argument of Hwang et al. (2020) that inquiry-based learning supported by technology can enhance students' higher-order thinking skills.

Table 7. Summary of normality test for cognitive domain learning outcomes

School Names	Data	Asymp.Sig (2-tailed)	Status
SMA 2 Padangsidimpuan	Normalized Gain for the Experimental Class	1.000	Normal
SMA 2 Padangsidimpuan	Normalized Gain for the Control Class	0.456	Normal
SMA 5 Padangsidimpuan	Normalized Gain for the Experimental Class	0.986	Normal
SMA 5 Padangsidimpuan	Normalized Gain for the Control Class	0.456	Normal

Analysis of research data confirms that parametric analysis assumptions have been met, enabling t-test evaluation of the IPSIA model's effectiveness. The demonstrated effectiveness of the IPSIA model can be attributed to several key factors: First, the integration of animation into inquiry learning facilitates students' visualization of abstract chemistry concepts, aligning with Koponen and Nousiainen's (2018) findings on dynamic visualization enhancing conceptual understanding in science education. Second, the model's scientific approach promotes active student engagement, supporting Duran and Dokme's (2016) assertion that inquiry-based active learning enhances student motivation, engagement, and cognitive outcomes. Third, the technological integration enables enhanced learning personalization, correlating with Burgess's (2023) findings that technology-based personalized learning accommodates diverse learning needs while improving overall educational effectiveness.

Although the study results demonstrate the effectiveness of the IPSIA model, it is important to note that implementing innovative learning models requires adequate support and preparation. As mentioned by Peng et al. (2023), the success of technology integration in education depends on teacher readiness, technological infrastructure, and institutional support. The implementation of the IPSIA model shows great potential in enhancing students' cognitive learning outcomes in chemistry subjects. However, further research is needed to evaluate the long-term impact and applicability of this model in broader contexts.

Evaluation

In the evaluation stage, two activities were carried out by the researchers: a) Analyzing suggestions and revisions from the implementation results of the previous stages—analysis, design, development, and implementation. This ensures that input, ideas, and feedback from experts/stakeholders (through focus group discussions) are considered before finalizing the IPSIA learning model; b) Compiling supporting documents for the model. These supporting documents include all forms of instruments, the model book, the teacher's book, and the student's book.

Conclusion

This study develops a valid, practical, and effective IPSIA learning model aimed at improving chemistry learning outcomes for high school students. The model combines a structured approach with the 5M scientific method and animation media, which enhances student engagement and supports cognitive, psychomotor, and affective development. The research findings indicate that implementing the IPSIA model significantly contributes to improved student learning outcomes.

Conflict of Interests

The author declares that there is no conflict of interest in this research and manuscript.

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