

The Effect of the Application of BSCS 5E Instructional Design on Communication Skills and Student Learning Outcomes in Physics Subjects at SMAN 16 Batam

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Abstract: his study aims to determine the effect of applying the BSCS 5E instructional model on students' communication skills and learning outcomes in physics at SMAN 16 Batam. The background of this research is the low level of students' communication skills and learning outcomes, which requires an innovative learning approach that is more active and student-centered. The study employed an experimental method with a quasi-experimental design. The subjects consisted of two classes: the experimental class using the BSCS 5E model and the control class using the TPACK model. The research instruments included a learning outcomes test and communication skills observation sheets. Data were analyzed using normality and homogeneity tests, followed by an independent t-test to examine significant differences between the two groups. The results revealed that the application of the BSCS 5E model had a significant impact on improving students' communication skills and learning outcomes. Students in the experimental class were better able to express ideas scientifically and achieved higher learning outcomes compared to those in the control class. Therefore, the BSCS 5E instructional model proved to be effective in enhancing communication skills and learning outcomes in high school physics learning.

Keywords: Application; BSCS 5E instructional design; Communication skills; Learning outcomes; Physics

Introduction

The rapid advancement of science and technology in the 21st century has transformed almost every aspect of human life, ranging from communication, transportation, and industry to education and social interaction. This condition requires education not only to function as a medium of knowledge transfer but also as a strategic effort to develop human resources who are creative, adaptive, and competitive at the global level. Physics, as one of the fundamental branches of natural sciences, plays a pivotal role in providing students with

conceptual understanding, analytical abilities, and practical insights to address real-world phenomena (Khasanah, 2021).

Physics education, therefore, should not be viewed merely as a process of memorizing formulas or mastering theories but rather as a holistic learning experience that sharpens critical thinking, analytical reasoning, and scientific problem-solving skills. Equally important, it provides opportunities to cultivate communication skills, collaboration, and creativity. These competencies are urgently needed to prepare students to navigate complex problems, bridge the gap

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between theory and practice, and participate actively in the advancement of science and technology (Maryanti et al., 2012).

Communication skills, in particular, are increasingly recognized as a core element of 21st-century learning outcomes. In the context of physics, students are required not only to understand abstract and complex concepts but also to be able to articulate, present, and defend their ideas clearly and logically. Mastery of communication skills enables them to engage in scientific discourse, exchange perspectives, and simplify sophisticated concepts into forms that are easier to understand, whether in academic, professional, or everyday contexts (Meiulianawati et al., 2024).

Nevertheless, empirical evidence in schools shows that students' communication skills in physics are still relatively weak. Many students find it difficult to express their scientific ideas systematically, whether orally or in writing. Teachers, on the other hand, often rely on conventional instructional models such as TPACK, which are relatively effective in structuring learning but not fully optimal in encouraging active participation, inquiry-based exploration, and meaningful scientific discussion (Technology, 2024).

This reliance on teacher-centered practices frequently results in monotonous classroom activities and passive student involvement. Students tend to memorize material without truly understanding the underlying concepts, which in turn weakens their ability to communicate ideas scientifically. This condition contributes to learning environments that fail to

stimulate curiosity, hinder the development of communication competence, and ultimately limit the achievement of higher-order learning outcomes expected from physics education. As stated by (Susanto et al. (2023) preliminary data collected at SMAN 16 Batam during the 2024/2025 academic year further underline this issue. In topics such as quantities and measurements, a significant number of students displayed limited comprehension, which directly affected their performance in expressing learning results. Such difficulties not only reduce test scores but also impede students from participating actively in class discussions, presenting experimental results, and engaging critically with peers and teachers.

Addressing these challenges requires the adoption of an innovative instructional design that simultaneously fosters conceptual mastery and communication ability. One promising approach is the BSCS 5E instructional model, which organizes learning into five systematic stages: engage, explore, explain, elaborate, and evaluate. Each stage is deliberately designed to activate prior knowledge, promote hands-on exploration, encourage scientific explanation, extend application of concepts, and reflect critically on learning outcomes.

Observation of student learning outcomes conducted by researchers at SMAN 16 Batam in the odd semester exam of the 2024/2025 academic year with the material of quantities and measurements obtained the following data.

Table 1. Odd Semester Assessment of Physics Subjects in Phase E Class of SMAN 16 BATAM in the 2024/2025 Academic Year

Learner Outcomes	Class E1	Class E2	Class E3	Class E4	Class E5	Class E6	Class E7	Class E8
Many Learners Have Not Achieved Learning Objectives (0- 65)	23	23	26	9	17	21	17	14
Many Learners Have Achieved Learning Objectives (66-100)	11	8	9	27	18	13	19	21
Number of Learners (people)	34	31	35	36	35	34	36	35
Highest score	85	75	88	89	83	85	83	85
Lowest score	23	18	23	28	23	28	25	33
Class average score	56	48	54	65	61	58	59	62

From table 1 above, it can be seen that the physics learning outcomes where there are still many students who get scores below the standard. In some classes the number of students who have not achieved the learning objectives is more than those who have achieved the learning objectives.

The low learning outcomes obtained by students are caused by several factors. Factors that affect learning outcomes can be internal factors, external factors and learning approach factors (Damayanti, 2022). It is important for teachers to design an innovative teaching

and learning process and utilize learning media teaching materials and use learning models that are in accordance with student conditions. With the right approach, learning objectives can be achieved and student learning outcomes are optimally improved.

In addition to improving learning outcomes through test scores, physics learning is also expected to develop students' communication skills to be more confident in conveying ideas and collaborating actively. Encouraging students to discuss, present their thoughts, and build constructive dialog is an important step in

creating effective and meaningful learning. Research by Khasanah (2021) shows that students' communication skills in online physics learning are still low, with a percentage of 28%, so efforts are needed to improve these skills.

Hope for a solution to this problem remains wide open. One promising approach is the application of the BSCS 5E instructional design model designed to actively engage students in learning through five stages: engage, explore, explain, elaborate and evaluate. This model not only helps students understand the theory but also encourages them to explore, share findings and apply knowledge in real life. Communication skills can be trained through appropriate teaching methods and learning resources with the LC 5E-based learning model (Learning Cycle 5E) using the Learner Activity Sheet (Anisah et al., 2022). This model allows students to actively participate in every stage of learning, so that their communication skills can develop through discussion, presentation, and collaboration.

Through the application of the BSCS 5E instructional design model, students are expected to be more confident in conveying their scientific ideas and findings both orally and in writing. In addition, this approach can also help students understand physics concepts more deeply because they learn through direct experience and reflection on their learning process. It is hoped that this improvement in communication skills and understanding will produce a generation that is better prepared to face global challenges. Research by Anisah et al. (2022) proved that the implementation of the BSCS 5E instructional design learning model is effective for improving students' communication skills.

The BSCS 5E instructional design model focuses on active student engagement through five systematic stages that support students' cognitive and skill development. The Engage stage is designed to capture students' attention through trigger questions or interesting phenomena, providing opportunities to practice speaking courage. The Explore stage encourages independent or collaborative exploration through experiments that enhance interpersonal communication skills such as discussion and idea sharing.

At the Explain stage, students explain the results of their exploration by connecting them to the theory, practicing structured communication orally and in writing. The Elaborate stage expands students' understanding by applying concepts to new situations, practicing critical thinking, creativity, and cooperation skills. The Evaluate stage invites students and teachers to reflect on learning through various evaluation methods, while honing the ability to present arguments effectively.

The Learning Cycle 5E learning model has been proven effective in improving communication skills and student learning outcomes. Through stages such as discussions and presentations, this model provides many opportunities for interaction that encourage students to participate more actively. The experiential approach in the Explore and Elaborate phases allows students to understand abstract concepts in depth, while improving their critical thinking skills. This is in line with the findings of Maizuroh et al. (2016) which showed that the application of the Learning Cycle 5E model can significantly improve students' communication skills.

Method

The research employed a quantitative approach with a quasi-experimental design, specifically the non-equivalent control group posttest-only design. This design involves experimental and control groups that are not randomly formed and only measured after the treatment (posttest). It is commonly applied in educational settings where classes are pre-determined and full randomization is not feasible.

In this study, the subjects consisted of two groups: the experimental group and the control group. Initially, pretests were conducted on eight classes of the lever phase at SMAN 16 Batam to identify classes with similar characteristics. The selection was based on comparable average scores, learning materials, teaching hours, and the teacher in charge. This initial measurement ensured that both groups had relatively equal conditions before treatment was administered.

To determine the final groups, a random sampling technique was used. Class names were written on paper, rolled up, and drawn randomly. The class selected became the experimental group, while the remaining class served as the control group.

The experimental group was taught using the BSCS 5E instructional model, while the control group used the TPACK model as a comparison. The presence of a control group allowed the researcher to evaluate whether improvements in the experimental group were truly due to the treatment or influenced by external factors.

This design offers several advantages for school-based research. It is practical because it does not require full randomization of subjects, which is often difficult in pre-existing class structures. The posttest-only format also increases efficiency by reducing time and resource demands, while avoiding the testing effect, namely the tendency of participants to adjust responses based on earlier tests. Thus, the design enhances both the practicality and validity of the study's findings.

Table 2. Normality Test of Pre-test and Post-test Data of Experimental and Control Classes (Sugiyono, 2021)

Group	(Treatment)	Post-test
Experimental	X	RE2
Control	-	RK2

Description: RE1: Pre_test of experimental class before treatment; RE2: Post-test of experimental class after treatment; X : Treatment or intervention given to the experimental group.

The hypothesis in this study was analyzed using t-test with polled variance. The ideal mean and ideal standard deviation criteria can be seen in Table 2.

Table 3. Criteria for Ideal Mean and Ideal Standard Deviation

Real Score Range	Category
50.95 = X < 67.9	Very high
39.65 = X < 50.95	High
28.35 = X < 39.65	Medium
17.05 = X < 28.35	Low

Result and Discussion

Result

The research employed a quantitative approach with a quasi-experimental non-equivalent control group posttest-only design. This method was chosen because classes in schools are pre-formed, making full randomization impractical. The design allows

researchers to measure learning outcomes after the treatment and assess the effectiveness of the instructional model applied.

The posttest results show that students who learned through the BSCS 5E instructional model achieved an average score of 71.12 on the topic of Renewable Energy Sources. This indicates that most students reached a satisfactory level of understanding and that the model had a positive influence on their academic achievement. Unlike conventional approaches, BSCS 5E emphasizes active participation, exploration, and reflection, enabling deeper conceptual mastery.

The learning process in the Engage and Explore stages provided students with real-life contexts, stimulating curiosity through observations, discussions, and simple experiments. These experiences created a solid foundation for understanding, which was strengthened during the Explain and Elaborate stages, where students were able to articulate and apply concepts with greater confidence.

Improved outcomes were also supported by the Evaluate stage, which included reflective discussions and teacher feedback. This step helped students refine their understanding, address misconceptions, and enhance both critical thinking and communication skills. Thus, the posttest scores not only represent content mastery but also reflect progress in students' analytical and metacognitive abilities.

Table 4. Frequency Distribution of Posttest Learning Outcomes in the Experimental Class

Class interval	Absolute Frequency	Relative Frequency	Cumulative Absolute Frequency	Cumulative Relative Frequency
55 – 61	9	30.30%	10	30.30%
62 – 68	1	15.20%	15	45.50%
69 – 75	13	27.30%	24	72.70%
76 – 82	5	12.10%	28	84.80%
83 – 89	2	6.10%	30	90.90%
90 – 96	3	9.10%	33	100.00%

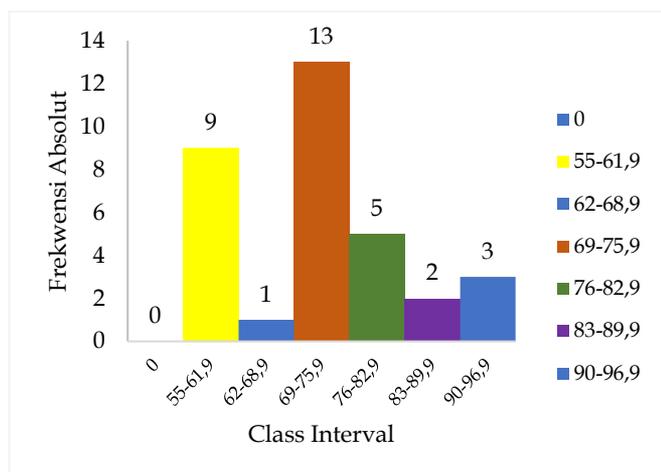


Figure 1. Histogram of posttest learning outcome frequency distribution experimental class

Based on the histogram shown, 23 students scored above 70 on the posttest. This achievement shows that the majority of students have understood the material on renewable energy sources quite well. However, there are still some students who have not reached the minimum passing standard, indicating the need for additional assistance. This is important so that their understanding of the material can be improved more optimally and evenly across the class.

In the posttest, the highest score obtained by students was 95, while the lowest score was 55. With a maximum score of 100, this data shows that there is still room for improvement in learning outcomes, especially for students whose scores are still below average. This situation also serves as a basis for evaluation in developing more effective and adaptive learning strategies. To support the analysis of communication

skills, further observation results are presented in the form of a frequency distribution in the following table.

Based on the frequency distribution data, 14 students obtained scores above the average, indicating that most students were able to understand the material well after participating in learning using the BSCS 5E model. The data visualization in the form of a histogram shown in Figure 3 provides a clearer picture of the distribution of students' posttest scores. The histogram shows that the highest frequency is in a specific score range obtained by 13 students. This indicates that most students are in a relatively high score range, reflecting the effectiveness of the implemented learning model. Thus, the relatively even distribution of scores and the dominance of scores above the average can serve as one indicator of the success of the BSCS 5E-based learning approach in improving students' learning outcomes on the topic of renewable energy sources.

The post-test results of students after participating in learning using the BSCS 5E model show that the highest score achieved was 95, while the lowest score recorded was 55 out of a maximum score of 100. This range of scores indicates that most students have understood the material quite well, but there are still significant differences between students in the high and low score categories. This difference indicates variations in the ability to understand concepts and solve problems, which may be influenced by differences in learning styles, learning motivation, or the initial readiness level of each student toward the material being taught. The presence of students who scored below average indicates that there is still room for improvement in the learning process. Although the post-test average score is satisfactory, the presence of students with minimum scores indicates that the learning strategies used have not yet been able to fully reach the full potential of all students equally.

Table 5. Criteria for Ideal Mean and Ideal Standard Deviation

Class interval	Absolute Frequency	Relative Frequency	Cumulative Absolute Frequency	Cumulative Relative Frequency
7 - 9.4	11	33.30%	11	33.30%
9.5 - 11.9	2	6.10%	13	39.40%
12 - 14.4	12	36.40%	25	75.80%
14.5 - 16.9	1	3.00%	26	78.80%
17 - 19.4	4	12.10%	30	90.90%
19.5 - 21.9	3	9.10%	33	100.00%

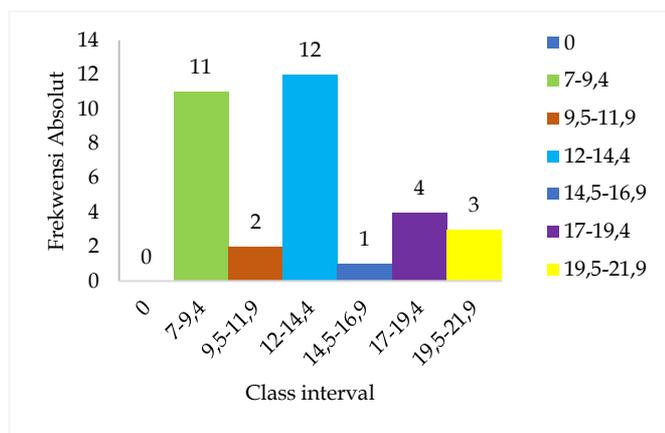


Figure 2. Frequency distribution experimental class frequency distribution histogram of communication skills in the experimental class

Referring to Figure 2, there are 12 students who obtained the highest frequency in the communication skills observation results, with scores ranging from 12 to 14.4. This finding indicates that the majority of students have fairly good communication skills, especially in terms of expressing opinions, listening actively, and contributing to class discussions. Given that the maximum score in this observation is 20, there is still room for all students to develop their communication

skills through a more systematic, collaborative, and active learning approach.

Learning outcome data and questionnaire responses were collected through pre-tests and post-tests administered to students in Phase E Hamka class at SMA Negeri 16 Batam in physics lessons on the topic of renewable energy sources. This class consisted of 35 students who were the subjects of the study. The post-test was conducted after the learning process to assess the progress of student learning outcomes. A complete statistical description of the pre-test results is presented in the following section.

The data presented is the posttest results of students in the control class. Based on these results, the lowest score obtained by students was 35, while the highest score reached 85. This variation in scores reflects a gap in understanding among students regarding renewable energy sources. This finding also indicates that most students in the control class have not achieved optimal understanding, which may be due to teaching methods that do not actively engage students and fail to connect the material to real-life contexts. To illustrate the distribution of learning outcomes in greater detail, the frequency distribution of the post-test data is presented in the following section.

The data presented is the result of a posttest administered to students in the control class, which is the class that followed conventional instructional models. Based on these results, it was found that the lowest score obtained by students was 35, while the highest score reached 85. This wide range of scores indicates a disparity in students' understanding of the material studied, particularly regarding the topic of renewable energy sources. This suggests that most students have not achieved an optimal level of understanding, with only a small proportion able to comprehend the material well and answer questions correctly.

These differences in learning outcomes illustrate that learning in the control class had less of a significant impact on students' overall competency achievement. One of the main causes of suboptimal learning outcomes is a passive learning approach, where students are not actively involved in the process of discovering and building understanding. Learning methods that do not provide real-world contexts or direct experiences make it difficult for students to relate the material to everyday situations. As a result, the learning process becomes less meaningful, and students' understanding of physics concepts such as solar energy, water, and biomass becomes superficial.

Table 6. Criteria for Ideal Mean and Ideal Standard Deviation

Class interval	Absolute Frequency	Relative Frequency	Cumulative Absolute Frequency	Cumulative Relative Frequency
35 - 43.4	7	20.00%	7	20.00%
43.5 - 51.9	7	20.00%	14	40.00%
52 - 60.4	10	28.60%	24	68.60%
60.5 - 68.9	2	5.70%	26	74.30%
69 - 77.4	4	11.40%	30	85.70%
77.5 - 85.9	5	14.30%	35	100.00%

Based on the results of statistical analysis of the posttest data on student learning outcomes in the control class, the average score was 56.93. This score indicates that, in general, student learning outcomes are still below the minimum standard of achievement that has been set. From the frequency distribution results, it was recorded that 16 students achieved scores above the average. This indicates that there is a group of students who have a better understanding of the material compared to other students in the same class.

Meanwhile, most of the other students still obtained scores below the average, indicating a gap in their mastery of the material. This situation requires further attention, particularly in designing more appropriate learning approaches to support improvements in student learning outcomes. More interactive and student-centered approaches could serve as alternative solutions to bridge these ability gaps. To provide a more detailed overview of the post-test results distribution, the data visualization is presented in the form of a histogram in Figure 3.

The data collected in this study includes learning outcomes and observations of students' communication skills. The data was then analysed to test the hypotheses formulated in the study. Before testing the hypotheses, prerequisite tests were conducted, including normality and homogeneity tests, to ensure that the data met the basic assumptions of inferential statistical analysis.

Only data that is normally distributed and homogeneous can be used in hypothesis testing. The normality test aims to determine whether the data is normally distributed, while the homogeneity test is used

to test the similarity of variances between groups. The following presents the results of the normality test, homogeneity test, and hypothesis testing of the questionnaire data and student learning outcomes.

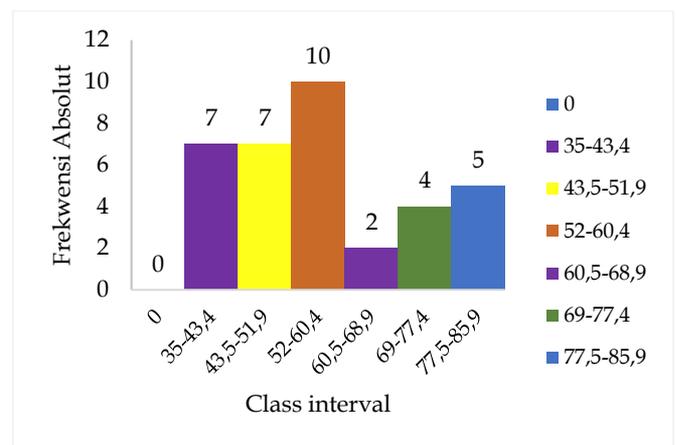


Figure 3. Frequency distribution experimental class frequency distribution histogram of communication skills in the experimental class

A normality test was conducted to determine whether the learning outcome data obtained from the experimental class and control class followed a normal distribution. This test is an important requirement before parametric statistical analysis can be performed. In this study, the normality test was conducted using Microsoft Excel software.

The criteria used in the test are: if the calculated L value is less than the table L value at a significance level of $\alpha=0.05$, the data is considered to follow a normal

distribution. Conversely, if the calculated L value is greater than the table L value at a significance level of $\alpha=0.05$, the data is deemed not to follow a normal distribution. The complete results of the normality test for the students' learning outcomes data are presented in the following section.

Table 7. Results of Normality Tests on Learning Outcomes in the Experimental Class and Control Class

Sample	L_{count}	L_{table}	Description
Experimental	0.1335	0.1544	Normal
Control	0.1061	0.1498	Normal

The normality test was conducted using Microsoft Excel software, and the results of the learning outcomes calculation showed that the L_{count} value was 0.1335. Meanwhile, the L_{table} value for a sample size of 33 students at a significance level of $\alpha = 0.05$ was 0.1544. Because the L_{count} value was $< L_{table}$, it can be concluded that the learning outcome data in the experimental class followed a normal distribution. Similarly, in the control class, the L_{count} value is 0.1061. Meanwhile, the L_{table} value for a sample size of 35 students at a significance level of $\alpha = 0.05$ is 0.1498. Since the L_{count} value is less than the L_{table} value, it can be concluded that the learning outcome data in the experimental class follows a normal distribution. This indicates that the data from the experimental class and the control class meet one of the prerequisites for parametric statistical analysis.

The results of the normality test for communication skills show that the L_{count} value is 0.1533. Meanwhile, the L_{table} value for a sample size of 33 students at a significance level of $\alpha = 0.05$ is 0.1544. Since the L_{count} value is less than the L_{table} value, it can be concluded that the learning outcome data in the experimental class follows a normal distribution. Similarly, in the control class, the L_{count} value is 0.1440. Meanwhile, the L_{table} value for a sample size of 35 students at a significance level of $\alpha = 0.05$ is 0.1498. Since the L_{count} value is less than the L_{table} value, it can be concluded that the learning outcome data in the experimental class follows a normal distribution.

Table 8. Results of Normality Tests on Learning Outcomes in the Experimental Class and Control Class

Sample	F_{count}	F_{table}	Conclusion
Experimental	0.5347	0.5575	$F_{count} < F_{table}$
Control			
Experimental	1.3310	1.7830	
Control			

From the results of the homogeneity test between the experimental class and the control class, the F_{count} value was 0.5347, while the F_{table} value was 0.5575.

Since the F_{count} value $< F_{table}$, it can be concluded that the data variance from both classes is uniform or homogeneous. This means that the data from both groups meets the requirements for further analysis using parametric statistical methods at a significance level of 0.05. From the results of the homogeneity test between the experimental class and the control class for students' communication skills, the F_{count} value was 1.3310, while the F_{table} value was 1.7830. Since the F_{count} value is less than the F_{table} value, it can be concluded that the data variance of both classes is uniform or homogeneous. This means that the data from both groups meet the criteria for further analysis using parametric statistical methods at a significance level of 0.05.

Discussion

Based on the results of the latest data analysis, the implementation of the BSCS 5E learning model has been proven to have a significant positive impact on improving students' communication skills in physics learning at the high school level. This model encourages students to actively engage in the learning process through five interconnected stages: Engage (connecting), Explore (exploring), Explain (explaining), Elaborate (elaborating), and Evaluate (evaluating). Each stage is designed to encourage students to think critically and interact actively, thereby creating a collaborative and communicative learning environment.

Recent research and meta-analyses indicate that the 5E learning cycle approach is effective in enhancing motivation, physics learning outcomes, and critical thinking skills among students, which are closely related to scientific communication skills, particularly in topics such as momentum and static fluids (Kun Prasetyo et al., 2024). These findings reinforce the evidence that the Explain and Elaborate phases in the 5E model play a significant role in helping students communicate ideas clearly, coherently, and logically.

In the Engage stage, students are guided to connect their prior knowledge or experiences with the physics concepts they are about to learn. This process creates cognitive connections between existing information and new material, helping students build a deeper understanding. The main objective of this stage is to foster interest in learning and encourage active student engagement in the learning process from the outset. The application of the Contextual Learning Approach can increase student activity in learning, broaden their horizons, deepen their understanding, and help students practise the material and reflect on each piece of knowledge to achieve learning objectives (Febrianto et al., 2024). Teachers can utilise relevant trigger questions related to everyday life contexts. In this study,

students learned about renewable energy topics to stimulate genuine curiosity among students.

This stage not only serves to attract attention, but also opens up space for initial interaction between students and teachers as well as among students. When asked to express their opinions, share experiences, or respond to real situations presented, students begin to be trained to express ideas verbally in a supportive environment. This activity provides students with the opportunity to begin developing communication skills, such as presenting thoughts in a logical manner, responding to others' perspectives, and building confidence in communicating in public. Individuals who are confident tend to be able to communicate effectively (Chairunnisa et al., 2024).

In other words, the Engage stage serves not only as an introduction to the subject matter, but also as the initial foundation for creating an open and collaborative learning environment. The emotional and intellectual engagement that emerges at this stage is an important stepping stone in developing students' communication skills in subsequent stages of learning (Asnur et al., 2025). A collaborative learning environment, interactive learning, and the availability of learning facilities have a positive and significant impact on improving students' academic performance (Yenita, 2024).

The Engage stage in the BSCS 5E model serves to connect learners' initial experiences with new concepts to be studied, thereby stimulating sustained interest and motivation to learn. Furthermore, the interaction process that occurs at this stage is very important in creating a communicative and collaborative classroom atmosphere, which forms the basis for the development of students' communication skills. The application of collaborative learning is intended to hone students' skills in discussing and expressing opinions, participating, organising, problem-solving, and creating new understandings in learning (Saputra et al., 2019). If students are not directly involved in the learning process, they will easily become bored. Students who are passive in learning, easily bored, lack interest in the subject matter, and do not delve deeply into what they are learning are indicators of declining student engagement (Bergdahl et al., 2024; Fitriyani et al., 2021; Georgopoulou et al., 2024).

Furthermore, the Elaborate stage in the BSCS 5E model is designed to facilitate the application of physics concepts in real-life situations. In this phase, students develop a deeper understanding through tasks that are relevant to their daily lives, thereby increasing meaning for them and sharpening their motivation to learn. Research shows that the use of the 5E model based on Contextual Teaching and Learning strengthens creative thinking skills and mastery of physics material (Evitasaki et al., 2024). The results of this study reinforce the view

that constructivist-based learning models contribute significantly to improving students' cognitive learning outcomes. In constructivist learning such as BSCS 5E, students act as active subjects who construct their own knowledge through guided learning experiences. This differs from traditional approaches that tend to position students as recipients of information.

Thus, the BSCS 5E approach has proven effective in creating an interactive, challenging, and meaningful learning environment. This environment encourages curiosity, intrinsic motivation to learn, and higher-order thinking skills, which are essential for mastering physics material. This aligns with previous research stating that implementing a constructivist approach through the Learning Cycle 5E model can enhance students' learning competencies in terms of knowledge, attitude, and skills (Wardhani et al., 2022). Therefore, the application of the BSCS 5E model is highly recommended in physics education at the high school level, not only to improve cognitive learning outcomes but also to foster students' independent, reflective, and future-ready learning challenges. Overall, these findings have important implications for educators in designing effective physics learning. Teachers are advised to apply the BSCS 5E model so that students can develop communication skills while improving their learning outcomes. This approach helps create an interactive and collaborative learning environment, which is essential in 21st-century science education. With consistent implementation, it is hoped that the quality of physics education at SMAN 16 Batam will continue to improve significantly.

Conclusion

Based on the results of the research and discussions that have been conducted, it can be concluded that the application of the BSCS 5E instructional design has a significant effect on improving students' communication skills and physics learning outcomes. Students who participated in learning with this model demonstrated better communication skills compared to those taught using the TPACK instructional design. They were more active in delivering information, able to express ideas effectively, and showed higher participation in discussions and question-and-answer sessions. Moreover, students appeared more confident in accurately using scientific physics terminology throughout the learning process. The findings also revealed that the learning outcomes of students who engaged in learning with the BSCS 5E model were significantly higher than those of the control group. This indicates that the systematic structure of the BSCS 5E model—through the stages of engage, explore, explain, elaborate, and evaluate—directly contributes to strengthening a deeper and more comprehensive

understanding of physics concepts. This approach provides a more meaningful and contextual learning experience, enabling students to establish strong connections between theory and real-life applications (Taali et al., 2024). Overall, the implementation of the BSCS 5E instructional design proved effective in enhancing both the cognitive and communicative aspects of students. This model improved students' ability to articulate ideas in a coherent and logical manner, pose critical questions, and respond confidently using terminology aligned with scientific principles. Thus, the BSCS 5E model not only supports improvements in academic achievement but also makes a positive contribution to the development of scientific communication skills, which are essential for 21st-century learning. In addition, this research and development also aimed to produce a Quantum Learning-based e-module that is valid, practical, and effective for use in IPAS Project learning on Economic Behavior and Social Welfare material in class X of SMK Negeri 6 Batam, using the ADDIE development model (Analysis, Design, Development, Implementation, Evaluation). The research results show that the e-module has fulfilled the criteria of validity, practicality, and effectiveness. In terms of validity, the e-module achieved an average score of 75% from media experts, 89.7% from subject matter experts, and 96.7% from language experts, indicating that it meets the required standards from multiple perspectives. Regarding practicality, the e-module obtained a score of 79% based on teacher questionnaires and 82% based on student questionnaires, which demonstrates that it is easy to use and well-received by both teachers and learners. In terms of effectiveness, the statistical test results revealed a t-value of 16.17, which is greater than the critical t-value of 1.697, confirming that the e-module is effective and suitable to be used as a learning medium to improve student learning outcomes. Therefore, this study confirms that the application of the BSCS 5E model and the development of a Quantum Learning-based e-module both contribute significantly to enhancing the quality of learning, not only by improving students' academic achievement but also by fostering their scientific communication skills.

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Author Contributions

Conceptualization and methodology, H. L. B.; software, validation, formal analysis, and investigation, H. L. B. and A.;

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Conflicts of Interest

There is no conflict of interest.

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