International Journal on Education Insight
Vol. 7, No. 2, April 2026, pp. 225-232
e-ISSN: 2722-2691 p-ISSN: 2722-2683 DOI: 10.12928/ijei.v7i2.15960
ORIGINAL RESEARCH PAPER

Enhancing students' cognitive ability on Newton laws through the integrated SSCS-TPACK learning model

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Abstract

This study aims to determine the effectiveness of the integrated SSCS-TPACK model, a model which integrates search-solve-create-share framework and technological-pedagogical content knowledge, in improving students' cognitive abilities regarding Newton's laws. In this study, effectiveness is operationally defined as a statistically significant increase in students' cognitive ability scores following the implementation of this learning model. This study employed a one-group pretest–posttest design involving 30 eighth-grade students from SMP Negeri 3 Peusangan, a public junior high school in Peusangan, Aceh, Indonesia. Participants were selected using a random sampling technique. Data were analyzed using a paired t-test. The results showed a statistically significant difference between pretest and posttest scores ($t = 29.08$, $p < 0.001$), indicating that students' cognitive abilities improved after learning with the integrated SSCS-TPACK model. These findings suggest that the integrated SSCS-TPACK model is effective in improving students' cognitive abilities in learning Newton's laws and therefore can serve as an alternative technology-integrated teaching approach to enhance the physics learning process.

Keywords: cognitive ability, Newton law, SSCS, TPACK

How to cite: Zikriana, L., Sharfina, Khairunnisak, & Safarati, N. (2026). Enhancing students' cognitive ability on Newton laws through the integrated SSCS-TPACK learning model. *International Journal on Education Insight, 7*(2), 225-232. https://doi.org/10.12928/ijei.v7i2.15960

Article history: Received 09/03/2026, Accepted 18/07/2026, Published 10/08/2026

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INTRODUCTION

Cognitive abilities encompass various qualities such as problem-solving, critical thinking, and memory. Students with strong cognitive abilities typically find it easier to understand course material and apply it in a broader context. There is a positive correlation between cognitive capacity and academic achievement, which students possessing high cognitive abilities earning higher grades (Saksana, 2024). Cognitive abilities are constructs that describe a person's mind or brain, and mental abilities encompass many skills, including planning, abstract thinking, rapid learning, and problem-solving. Students' cognitive development can be observed through their actions, which are driven by a high level of curiosity (Izzuddin, 2021). Students can develop these cognitive abilities through the constructivist learning process within the Merdeka Belajar Program. Through constructivist learning, students will develop the abilities to think, remember, solve problems, and make decisions. These abilities are integral components of the cognitive abilities possessed by students (Naufal, 2021).

The cognitive ability of students' is the primary goal of academic efforts to ensure continuous improvement. In addition, cognitive abilities serve the function of storing information, both short term and long term, enabling students to recall past experiences and retain them when needed. Cognitive skills also help students concentrate on events (Dear et al., 2022).

Cognitive abilities play a crucial role in science education. Most students in Indonesia still demonstrate low levels of science literacy. PISA 2022 reported an average science score of only 383, which is below the OECD average of 485. In terms of percentages, only 34% of students reached proficiency Level 2, compared to 76% in OECD countries, and almost none reached Levels 5-6. These results indicate difficulties in understanding concepts, applying knowledge, and solving problems (OECD, 2023).

Many students find physics difficult because the subject requires an understanding of abstract concepts and strong analytical skills. This situation is exacerbated by conventional teaching approaches that tend to be one-sided and non-interactive. Therefore, innovative teaching methods are needed to strengthen students' cognitive abilities (Shofiyah, 2024). One of the topics in physics that continues to pose a learning challenge for 10th-grade students is Newton's laws. Although students have been introduced to the concept of force and Newton's three laws during their junior high school education, their understanding is often limited to basic definitions and simple examples (Fatma et al., 2023). At the high school level, students are expected to apply Newton's Laws to analyze various physics phenomena, explain the relationship between force, mass, and acceleration, and solve contextual problems encountered in daily life. This transition from conceptual introduction to analytical application often leads to misunderstandings and low cognitive achievement, indicating that students need learning experiences that foster deeper conceptual understanding and scientific reasoning (Sarwanto et al., 2025). Therefore, an innovative learning model is needed to improve students' cognitive abilities in this subject.

One of the learning model considered suitable for improving students' cognitive abilities is the Search, Solve, Create, and Share (SSCS) model. The Search, Solve, Create, and Share (SSCS) model consists of four stages: the "search" stage, which aims to identify problems; the "solve" stage, which aims to find solutions to problems; the "Create" stage, which aims to produce and derive results or conclusions from problem-solving, and the "Share" stage, which aims to communicate and present the results of the problem-solving process (Sari et al., 2025).

To enhance students' cognitive abilities, the researcher applied the SSCS model integrated with TPACK (Technological, Pedagogical, and Content Knowledge). This knowledge, which integrates the use of technology into learning is known as technological pedagogical content knowledge (TPACK). This approach is crucial for improving the quality of both the learning process and outcomes (Jibril & Adedokun-Shittu, 2024; Sihanita et al., 2024; Thohir et al., 2022). Numerous studies, both in Indonesia and abroad, have extensively examined TPACK. Among them is a study by Joshi (2023), which confirms and expands our understanding of how TPACK empowers teachers to address teaching challenges in the digital age.

In this study, TPACK was applied by integrating instructional videos developed by the researcher and PhET simulations into each stage of the SSCS learning model. The instructional videos were used to introduce and explain the concepts of Newton's laws, while the PhET simulations allowed students to visualize the relationships between force, mass, and acceleration and to interactively investigate physical phenomena while completing worksheets. In the context of learning, integration of teachers' understanding of educational technology, pedagogical knowledge, and subject matter expertise plays an important role in creating effective learning experiences (Janah, 2022). Educational videos presented appropriately and engagingly can enhance students' cognitive abilities and help them focus on learning. Currently, instructional videos have become a commonly used teaching resource by various educational institutions in a wide range of learning processes (Utama et al., 2021). Educational videos can assist students in the learning process and serve as an alternative learning method. In this context, video-based learning is more engaging than other learning resources, such as textbooks. Video-based learning offers the its audiovisual nature and can be repeated until students understand the concepts in line with the learning objectives (Anggraini et al., 2022).

Based on several previous studies, this study aims to examine the effectiveness of the SSCS model integrated with TPACK in enhancing students' cognitive abilities regarding Newton's laws. The objective of this study is to determine the effectiveness of the SSCS model integrated with TPACK in enhancing students' cognitive abilities related to Newton's laws.

RESEARCH METHOD

This study employed a pre-experimental research design with a single-group pretest-posttest design (Fraenkel et al., 2019). This design involved a single group of participants who took a pretest before the intervention and a posttest after the implementation of the SSCS model integrated with TPACK. The design was used to evaluate changes in students' cognitive abilities following the intervention.

The population consisted of 125 eighth-grade students spread across four classes at SMP Negeri 3 Peusangan. The sample was selected using a cluster random sampling method, in which one class was randomly selected from the four available classes. As a result, Class VIII.3, consisting of 30 students, was selected as the study sample. The data collection methods and instruments consisted of a multiple-choice questionnaire comprising 15 validated questions.

Data analysis in this study was conducted using a dependent t-test. The dependent t-test was used to test a single sample that received a treatment, and then to compare the sample's mean scores before (pretest) and after (posttest) the treatment. Cognitive ability data were analyzed using the N-gain formula as presented in Equation (1) (Meltzer et al., 2002).

$$g = \frac{S_{posttest} - S_{pretest}}{S_{max} - S_{pretest}} \tag{1}$$

The N-gain scores obtained were then analyzed using the criteria. The N-gain criteria are shown in Table 1 (Meltzer et al., 2002). Based on the N-gain score criteria, cognitive ability is considered effective if students achieve an N-gain score > 0.7, which means the high criterion. Furthermore, the hypothesis test for differences in cognitive ability can be described as follows.

Table 1. N-gain criteria

Interval	Criteria
0.70 – 1.00	High
0.30 – 0.69	Moderate
0.00 – 0.39	Low

Normality test

This study used a normality test based on the Lillifors formula, which showed that since the calculated $L < L_{table}$ so the data were normally distributed. This means that at a 5% significance level, the normalized N-gain scores for pre- and post-tests of cognitive ability in statistics come from a homogeneous population.

Homogeneity test

This study used a homogeneity test based on Harley's formula, which showed that since the calculated $F < F_{table}$ so the data were homogeneous. This means that at a 5% significance level, the normalized N-gain scores for pre- and post-tests of cognitive ability in statistics come from a normal population.

Dependent t-test

Based on the tests of normality and homogeneity of the gain scores, it can be determined that the gain scores are normally distributed and homogeneous. Therefore, the analysis proceeds to a test of the equality of two means using a paired t-test (dependent t-test). If $t > t_{table}$ the null hypothesis H_0 is rejected, indicating a significant difference in cognitive outcomes. Conversely, if $t < t_{table}$, H_0 is accepted which means that no significant exists.

RESULTS AND DISCUSSION

The implementation of the SSCS (Search, Solve, Create, and Share) model integrated with the Technological Pedagogical Content Knowledge (TPACK) framework was conducted over four meetings, with each meeting lasting approximately 90 minutes. The learning activities focused on Newton's Laws and were designed to improve students' cognitive abilities through student-centered learning supported by technology (See Figure 1).

(a) (b)

Figure 1. Teacher explains the steps for completing the worksheet (a), teacher guides the students in collecting data (b).

During the **search** phase, students are introduced to real-life scenarios related to Newton's laws through educational videos, animations, and PhET simulations. They are encouraged to identify the physical phenomena presented, formulate questions, and determine the concepts needed to solve these problems.

During the **solve** phase, students worked together in small groups to analyze the problems using the worksheets. Under the teacher's guidance, the students discussed various possible solutions by applying Newton's laws to a variety of contextual situations.

During the **create** phase, students organize the results of their discussions into concept maps and written explanations. The use of technology allows students to visualize physics concepts more effectively and present their ideas creatively.

Finally, in the **share** stage, each group presented their findings to the class using multimedia presentations. Other groups provided feedback and engaged in classroom discussions, while the teacher facilitated reflection, clarified misconceptions, and reinforced the correct scientific concepts. Throughout the implementation, the TPACK framework was reflected in the integration of technology, appropriate pedagogical strategies, and Newton's Laws content to support meaningful learning.

Students' cognitive ability

After implementing the SSCS model integrated with TPACK, students' cognitive abilities were analyzed by comparing their average pretest and posttest scores. This comparison was conducted to determine the extent to which this teaching approach improved students' cognitive abilities regarding Newton's laws.

Cognitive ability indicators are the levels of Bloom's Taxonomy used to analyze cognitive abilities, namely: knowledge (C1), comprehension (C2), application (C3), analysis (C4), evaluation (C5), and creation (C6). The cognitive ability indicators used in this study range from C1 to C4. The percentages of cognitive abilities are shown in Figure 2.

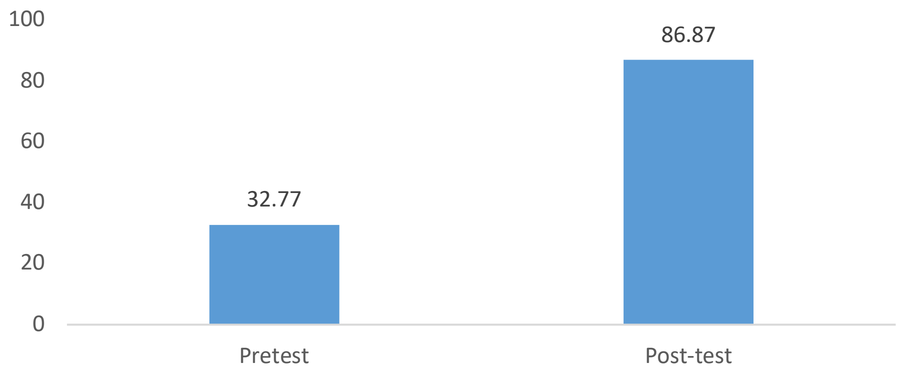

Figure 2. Percentages of cognitive abilities

Figure 1 shows that the pretest score was 32.77%, while the posttest score was 84.87%. Cognitive ability improved between the pretest and posttest, with an N-gain of 0.81, which falls into the high category. The N-gain for cognitive ability is shown in Table 2.

Table 2. N-gain cognitive ability

Variable	N-gain	Category
Cognitive Ability	0.81	High

Based on Table 2, the N-gain for students' cognitive abilities falls into the high category. This indicates that the integration of the SSCS learning model with TPACK effectively enhances students' cognitive abilities in Newton's Laws. Furthermore, the data must be normally distributed and homogeneous before a t-test can be conducted. The results are presented in Table 3.

Table 3. Dependent t-test cognitive ability

Data Source	Average Score	Normality (*Lillifors test*)	Homogeneity	Significance
Pretest	32.767	$L < L_{table}$ 0.141 < 0.161 "Normal"	$F < F_{table}$ 1.02 < 1.84 "Homogeneous"	$t < t_{table}$ 29.08 < 1.68 "Significantly Different"
Postest	86.867	$L < L_{table}$ 0.147 < 0.161 "Normal"		

In Table 3, the pretest average score was 32.767, and the normality test obtained $L < L_{table}$ data with a result of 0.141 < 0.161, indicating that the pretest data was normally distributed. Meanwhile, the average post-test score was 86.767, and the normality test showed that $L < L_{table}$ with a result of 0.147 < 0.161, indicating that the post-test data was normally distributed.

According to the criteria for testing the t-test hypothesis, if the $t < t_{table}$ and the result is 29.08 < 1.68, which means Ho is rejected and Ha is accepted. Based on the data above, the SSCS model integrated with TPACK is effective in enhancing students' cognitive abilities. The improvement in students' cognitive abilities indicates that student-centered learning provides broader opportunities for building conceptual understanding compared to learning that is solely oriented toward the delivery of information.

In this study, students not only received explanations from the teacher but were also actively engaged in observing phenomena, analyzing problems, testing ideas, and communicating their thoughts. This active engagement encourages students to connect prior knowledge with new information, thereby fostering a deeper conceptual understanding. This finding aligns with research (Andhini et al. 2024), which shows that the use of teaching materials based on illustrated envelopes significantly enhances students' cognitive abilities compared to learning that does not utilize such materials. This finding is supported by research (Zikriana et al. 2023) indicating that SSCS-based instructional materials integrated with TPACK meet validity criteria and are suitable for use in learning. Furthermore, the use of these materials also contributes to the development of students' scientific attitudes during the learning process. The implementation of the SSCS learning model has an impact on students' reflective thinking skills in mathematics (Yasin et al., 2020); their mastery of physics concepts (Yuliana et al., 2024); and their creativity and innovation skills, particularly as measured by indicators of creative thinking and the application of innovation (Tiyaswati, 2020).

The integration of TPACK provides a more meaningful learning experience through the use of instructional videos and PhET simulations. Instructional videos help students systematically understand the basic concepts of Newton's laws, while PhET simulations allow students to interactively observe the relationships between force, mass, acceleration, and motion. These visualizations help reduce the abstract nature of physics material, making it easier for students to interpret concepts and apply them to problem-solving. This supports the development of cognitive abilities, particularly in understanding, applying, and analyzing the concepts of Newton's laws. The results of this study indicate that the combination of the SSCS and TPACK models not only enhances students' learning activities but also creates a more meaningful learning process through the interaction between concepts, learning strategies, and technology. Therefore, the implementation of the SSCS model integrated with TPACK can serve as an effective alternative for physics instruction to enhance students' cognitive abilities regarding Newton's Laws. The SSCS problem-solving learning model combined with CPS has an impact on problem-solving skills (Zahroh et al., 2018), and the VAK model is capable of improving students' cognitive abilities regarding Newton's Laws (Aprilia et al., 2022).

CONCLUSION

Based on the research findings, the TPACK-integrated SSCS model is effective in improving students' cognitive abilities. The results of the dependent t-test showed that the calculated t significantly greater than the t_{table} (29.08 > 1.68), indicating a significant difference between the pretest and posttest scores.

ACKNOWLEDGEMENT

Not available.

DECLARATION

Author contribution

All authors contribute in the research and/or writing the paper, and approved the final manuscript.

Lissa Zikriana	Conceptualizing the research idea, leading the investigation, setting up the methodology, and writing the original draft.
Sharfina	Assisting the investigation, reviewing the validity of the methodology, and analyzing the data.
Khairunnisak	Assisting the investigation, reviewing the validity of the methodology, and analyzing the data.
Nanda Safarati	Assisting the investigation, reviewing the validity of the methodology, and analyzing the data.

Funding
This research did not receive any funding.

Conflict of interest
All authors declare that they have no competing interests.

Ethics declaration
We as authors acknowledge that this work has been written based on ethical research that conforms with the regulations of our institutions and that we have obtained the permission from the relevant institutes when collecting data. We support the International Journal on Education Insight (IJEI) in maintaining the high standards of personal conduct, practicing honesty in all our professional practices and endeavors.

The use of artificial intelligence
We do not use any generative AI tools to write any part of this paper.

Additional information
Not available.

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