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Development and Validation of the Integrated Socio-Scientific Issues and Discovery Learning Model: A New Instructional Model on Students' Critical Thinking Skills

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ABSTRACT

Innovative learning models have the potential to develop critical thinking skills. This study aims to develop and validate a socio-scientific issues discovery (SSID) learning model to improve students' critical thinking skills. The research design used Research and Development (R&D) using the steps proposed by Borg & Gall. This study only used five of the ten steps because it was adjusted to the research objectives to evaluate the feasibility and practicality of product development. The feasibility test of the socio-scientific issues discovery learning model and its tools used the Focus Group Discussion (FGD) method. Five experts conducted the feasibility test. The practicality test was conducted by five science teachers. Data were analyzed using quantitative methods. The results showed that the socio-scientific issues discovery learning model was feasible and practical to use in learning. Meanwhile, the results of the critical thinking skills test instrument validation showed that each item was valid for use. Therefore, it can be concluded that the socio-scientific issues discovery learning model has the feasibility and practicality to be used in learning to improve critical thinking skills.

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1. INTRODUCTION

Critical thinking skills are mental processes used to conceptualize, apply, analyze, synthesize, evaluate information, and decisions to reach an answer or conclusion to a problem (Changwong et al., 2018). The development of critical thinking skills is important to face the challenges and demands of the 21st century which has become a major goal in science learning (Carvalho et al., 2015 & Sadhu & Laksono, 2018). However, various studies show that the critical thinking skills of students in Indonesia are still relatively low. The results of critical thinking skills research in several regions in Indonesia such as Kediri (Fuad et al., 2017), Malang (Fauzi, 2019), Batang (Ridho et al., 2019), South Sulawesi (Suryani et al., 2020), and Bantul (Arti dan Ikhsan, 2020) still need to be developed. The gap in these studies is the lack of specific and comprehensive learning solutions to improve critical thinking skills through appropriate and applicable learning model syntax. Saputri et al. (2019) explained that low critical thinking skills indicate that the science learning process has not facilitated the development of critical thinking skills optimally. Patonah et al. (2021) suggested that critical thinking skills are still low due to the learning process that is oriented to the level of remembering and understanding. Critical thinking skills are very important to develop in learning. Astuti et al. (2020) explained that critical thinking skills are important to develop so that students can find solutions to their life problems. However, most of the solutions offered are still fragmented, failing to fully integrate cognitive and contextual dimensions into a systematic learning model.

Critical thinking skills affect learning outcomes. Mahanal et al. (2019) explained that optimal learning outcomes are determined by the learning process designed by the teacher. In addition, an important factor influencing the success of teaching and learning activities is determined by the learning model (Fauzi, 2019). The learning model is a systematic learning design that organizes learning experiences to achieve learning objectives (Moore, 2015). However, the dominant learning model currently used is still based on traditional patterns that do not provide students with space to explore independently and build their understanding. Khalaf et al. (2018) argue that there is a gap between the current learning model and the expectations of the education system in developing students' knowledge and skills, so appropriate reforms are needed in the field of learning by formulating new learning models. Various learning models have been attempted to be used in learning activities to develop students' critical thinking and communication skills. The results of Krahenbuhl (2016) state that the implementation of learning is more dominant for students who receive information from teacher explanations, not from finding sources of information. The learning process is monotonous due to the lack of teacher variety in applying learning models (Weiming et al., 2016). Learning focuses on achieving mastery of concepts so that students can complete the material according to curriculum targets (Al-Zoubi & Younes, 2015).

One of the learning models that can develop critical thinking skills is the discovery learning model. The discovery learning model has been recommended by the Kementerian Pendidikan dan Kebudayaan (2020) as one of the innovative learning models. Discovery learning is student-centered learning to provides opportunities for students to discover activities and disclose discovery information (Druckman & Ebner, 2017). However, this model does not fully involve social context and ethical values in the scientific discovery process carried out by students. Discovery learning can occur when students are not given the right answer but rather try to find the answer themselves (Zhou & Brown, 2017).

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The learning process also needs to pay attention to the involvement of students in the group for mutual respect. This is in line with the opinion of Kereluik et al. (2013) who explained that learning needs to equip students with thinking skills accompanied by good interpersonal skills. This condition encourages teachers to apply the socio-scientific issues learning model. The socio-scientific issues learning model is contextual learning that presents complex scientific social problems (Hancock et al., 2019) involving students in discussions (Sadler et al., 2019) to determine problem-solving decisions (Eggert et al., 2013) by considering morals and ethics (Foulk et al., 2020). Khishfe et al. (2017) explained that the socio-scientific issues learning model is a learning model that can develop an understanding of the nature and universal goals of science education. The socio-scientific issues learning model helps students to communicate like scientists to discuss scientific social issues (Emenaha, 2019) by considering the social, moral, political, and economic effects of science (Özden, 2015). However, the SSI model has not been widely developed in the form of explicit learning designs that are integrated with scientific discovery approaches such as discovery learning. Therefore, an integrative model is needed that not only trains scientific thinking processes but also develops students' social awareness and moral responsibility.

Based on the characteristics of the discovery learning model and socio-scientific issues, integration and modification are carried out into a new learning model, namely the socio-scientific issues-discovery learning model. The developed learning model is seen as a solution to improve critical thinking skills. Singh and Chibuye (2016) argued that learning designs that apply active and innovative learning models can facilitate students to develop their abilities so that learning objectives can be achieved optimally. Research on learning models to improve critical thinking skills has been widely conducted, but none has been specifically designed to modify the socio-scientific issues learning model and the discovery learning model in science learning. The socio-scientific issues discovery learning model has novelty in the resulting syntax because it combines the discovery learning model and socio-scientific issues.

The components of the learning model in this study refer to Joyce et al. (2015), namely rational theory, syntax, reaction principles, social systems, support systems, and instructional and nurturing effects. The main advantage of this model lies in its syntax, which is specifically designed to encourage scientific exploration based on real social issues faced by students. Therefore, the socio-scientific issues discovery learning model must be explained conceptually and pedagogically for science learning. The socio-scientific issues discovery learning model needs to examine its components, feasibility, and practicality. The research questions include (1) how the components of the socio-scientific issues recovery learning model can improve students' critical thinking skills; (2) how is the feasibility of the socio-scientific issues recovery learning model to improve students' critical thinking skills; (3) how is the practicality of the socio-scientific issues recovery learning model to improve students' critical thinking skills?

2. METHODS

2.1. Research Design

This research is a type of research and development (R & D) following Borg & Gall (2003) including (1); research and information collecting; (2) planning; (3) developing a preliminary form of product; (4) preliminary field testing; (5) main product revision; (6) main field testing; (7) operational product revision; (8) operational field testing; (9) final product

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revision; (10) dissemination and implementation. This study only used five of the ten steps because it was adjusted to the research objectives to evaluate the feasibility and practicality of product development. The stages of product development are presented in **Table 1**.

Table 1. Stages of Product Development

Stages	Activities
Preliminary Study	Literature study a. Science learning b. Characteristics of students c. Concept of discovery learning model and socio-scientific issues d. Study of critical thinking skills and communication skills e. Review of relevant research Field study a. Problems in the implementation of science learning b. Completeness of science learning tools
Planning	a. Determination of product specifications b. Design of product design in the form of learning model design and learning device design c. Product design grids in the form of learning model design grids and learning device design grids
Initial Product Prototype	a. Preparation of initial product prototypes in the form of learning model prototypes and learning devices b. Learning model validation instruments based on learning model design grids c. Learning device validation instruments based on learning device design grids d. FGD with Delphi technique. Delphi technique is chosen because there is an agreement of assessment among experts without groupthink or domination of one expert (Linstone & Turoff, 1975)
Initial Product Trial	The initial product trial aims to analyze the practicality, and readability of learning devices. The practicality trial involved 5 teachers to test the practicality of the application of the learning model and its tools. The readability trial involved 9 students selected based on the results of daily assessments with high, medium, and low abilities. The readability trial was to analyze the readability of the students worksheet.
Revision I	Revision based on the results of the analysis of the initial product trial by analyzing the practicality and readability of learning instruments in the form of students worksheet.

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2.2 Participants

The feasibility assessment of the socio-scientific issues learning model prototype involved five experts who are experienced in the field of learning models. The expert criteria used are doctoral degree, professor or associate professor position, 10 years of teaching experience, and expert in education, science, and learning theory. Science teachers are also involved in evaluating the practicality of the socio-scientific issues learning model with the criteria of 10 years of teaching experience. Feasibility assessment was conducted through Focus Group Discussion (FGD). The list of experts involved in the feasibility FGD of the socio-scientific issues learning model is presented in **Table 2**.

Table 2. List of Experts on the Feasibility of Socio-Scientific Issues Learning Model

Expert's title	Teaching field	Expertise
E-1: professor	Science education	Science instructional model
E-2: associate professor	Biology education	Science content material
E-3: associate professor	Chemistry education	Science content material
E-4: professor	Education science	Instructional theory
E-5: associate professor	Educational evaluation research	Critical thinking skills instrument

2.3 Instruments

The instrument used in this research is the socio-scientific issues (SSID) learning model product assessment sheet. This research involved five experts in the field of learning model development who came from internal and external environments of higher education. The feasibility assessment of the SSID learning model was carried out using expert judgment. The practical assessment of the SSID learning model was conducted by five teachers. Feasibility and practicality assessment using the Guttman scale. The Guttman scale is used to get answers from validators, firmly, and consistently (Guttman, 2017). The validator's assessment score is dichotomous in the form of Yes (score 1) and No (score 0) answers. Content validation of critical thinking skills instruments uses a four-point Likert scale with score criteria including without revision (4); minor revision (3), major revision (2), and cannot be used (1).

2.4. Data Analysis

The data analysis technique used to process the results of the feasibility and practicality tests used Aiken's V formula. Aiken's V formula according to Aiken (1985) uses the formula presented in Equation 1.

$$V = \frac{\sum s}{[n(c-1)]} \text{ .... Equation 1}$$

$$s = \sum ni\,(r - l_0)$$

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Description:
V : validity index
Ni : many validators who give criterion i
R : criterion i
N : number of validators
C : number of criteria
l_0 : lowest criterion

The calculation results obtained will produce a V index. Aiken (1985) provides guidelines for assessing product feasibility by comparing the V index. The product is declared valid if it has a V value ≥ 1, if the value is below 1, revisions need to be made according to the comments and suggestions of the validator.

The instrument to assess critical thinking skills consists of 5 items. Aspects of item validation include construction, material, and language. The results of content validity were analyzed using Aiken's V. The rating scale used is a Likert scale. The Likert scale used in this study amounted to 5 scales. Therefore, the product is declared valid if it has a V value ≥ 0.80, if the value is below 0.80, revisions need to be made according to the comments and suggestions of the validator (Aiken, 1985). In the critical thinking skills instrument, if it has met the valid criteria based on the results of the content validity test, the items are analyzed using the Quest program.

3. RESULTS AND DISCUSSION

3.1. Results

The results of the development of the SSID learning model are presented in **Figure 1**. This learning model consists of several components including rational theory, social systems, reaction principles, supporting principles, instructional impact, and accompanying impact.

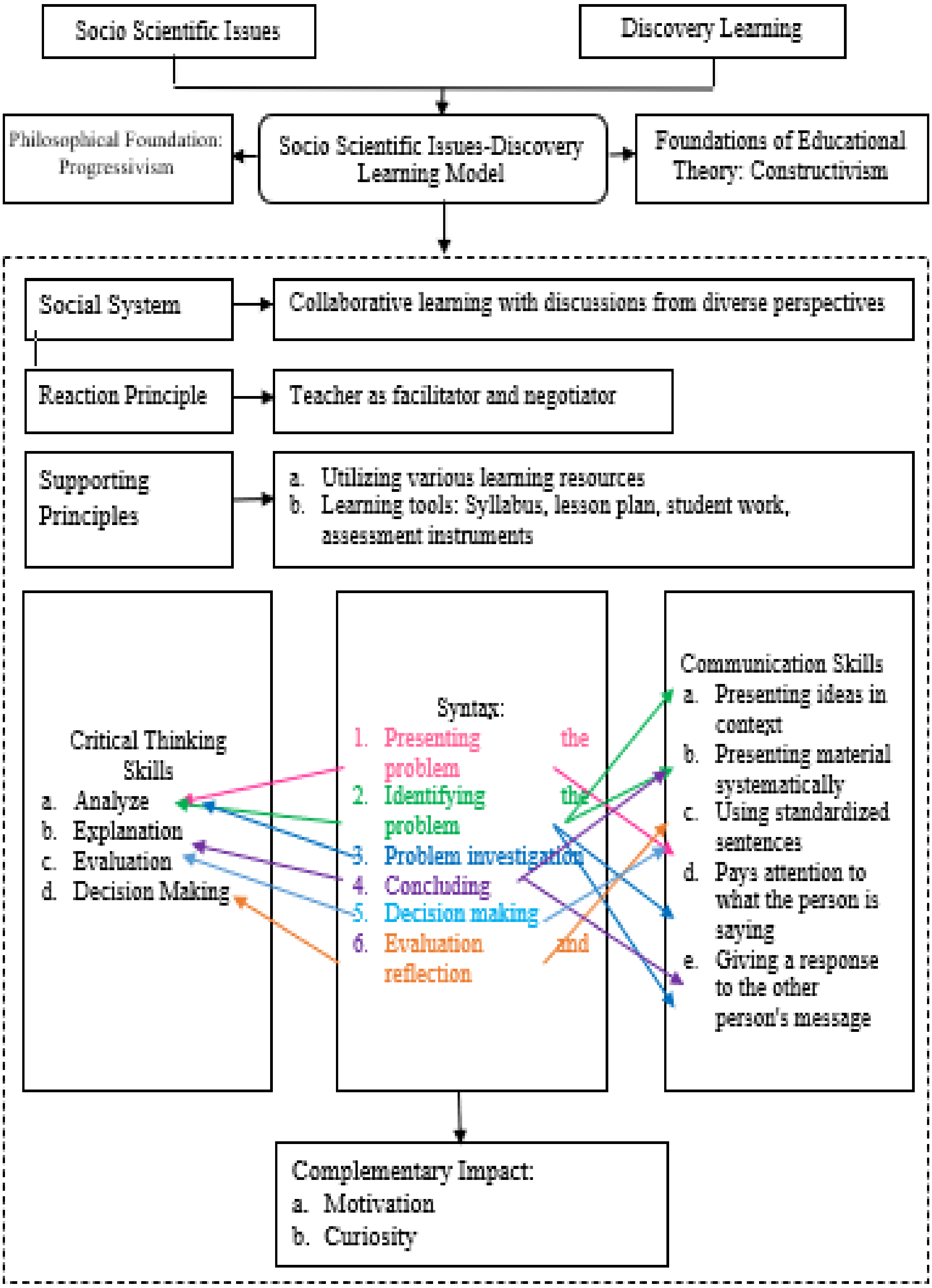

Figure 1. Components of the SSID Learning Model

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a. Component 1: Rational Theory

The learning theory underlying the development of the SSID learning model is the theory of constructivism. Aljohani (2017) explains that learning is an active process of constructing knowledge to contextualize meaningful learning. The characteristics of the SSID learning model are that the teacher acts as a facilitator and negotiator, not an authoritarian. The theoretical basis for designing the SSID learning model is Piaget's constructivism theory, Vygotsky's constructivism theory, and Bruner's constructivism theory.

Piaget's constructivism theory explains that cognitive development occurs in the process when students actively build meaning and understanding through real experiences. The learning process begins with real experiences experienced by students which are then reflected on individually. In this process, students will try to understand what is happening and being experienced. His theories of schema, assimilation, accommodation, and equilibration all relate to children's ability to construct their new knowledge cognitively in the stages of cognitive development. The theory becomes a reference in the development of syntax in the SSID learning model, which discusses topics that are relevant to students' lives to strengthen assimilation, accommodation, and equilibration.

The application of the SSID learning model also emphasizes the importance of social interaction which is the key to Vygotsky's constructivism theory. Social interaction can be formed by creating learning groups with different abilities so that students can interact and come up with strategies to solve problems. Social interaction will help students to spur the formation of new ideas and enrich their intellectual development. In addition, teachers play a role in assisting students when they experience difficulties in learning. When students' competence increases, the teacher gradually reduces scaffolding so that students can learn independently.

Bruner's constructivism theory explains that learning is a process that involves students actively by providing opportunities for students to discover concepts through interaction with the environment. Teachers should let students explore, reason and think, solve problems, discover facts or principles, and enjoy the happiness gained from their learning to foster curiosity.

b. Component 2: Syntax (Learning Process)

The syntax of the SSID learning model is presented in **Table 2**.

Table 2. Syntax of SSID Learning Model

Syntax	Teacher Activities	Students Activities
Presenting the problem	a. The teacher presents the problem through pictures/articles/video b. The teacher asks apperception questions c. Teacher presents the learning objectives	a. Students study the picture/article/video given by the teacher b. Students answer the teacher's questions c. Students look at the learning objectives
Identifying the problem	Guide students in analyzing the core of the problem presented.	Analyze the core problem presented by the teacher.
Problem investigation	a. Guide students to find and gather information to solve	a. Seek and gather information to solve

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Syntax	Teacher Activities	Students Activities
	problems from various perspectives. b. Guide students to share information in small groups to highlight complexity and share perspectives	problems from multiple perspectives. b. Share information in small groups to highlight complexity and share perspectives.
Concluding	Guide students to conclude the results of the problem investigation.	Students conclude the results of the problem investigation.
Decision making	Guide students to make appropriate problem solving solutions from various perspectives.	Students create appropriate problem-solving solutions from multiple perspectives.
Evaluation and reflection	a. Guide students in analyzing the advantages and disadvantages of the solutions made. b. Guide students to determine the best solution to solve the problem by considering morals and ethics.	a. Analyze the advantages and disadvantages of the solutions made. b. Determine the best solution to solve the problem by considering morals and ethics.

c. Component 3: Reaction Principle

The reaction principle describes the pattern of interaction between teachers and students that occurs in learning. The teacher acts as a facilitator of learning and helps direct the negotiation process carried out by students wisely to enable them to gain new knowledge. Teachers need to prepare to define the problem provide stimulus (Van Hong et al., 2017), engaging in various information-seeking processes (Eggert et al., 2013). Teachers must be willing to face the uncertainty of students' answers from various perspectives and sometimes teachers must position themselves as questioners and contributors of knowledge equal to students (Eastwood et al., 2011).

d. Component 4: Social System

The social system in this model is collaborative learning with discussions from diverse perspectives. Students are allowed to discuss collaboratively and interactively potential problems for the application of science concepts from diverse perspectives. Students are allowed to search, find, and solve problems by utilizing various learning resources. Discussion interaction to be productive and interesting, all students must show mutual respect, and consider morals and ethics in student participation, resulting in a meaningful learning process.

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e. Component 5: Support System

Teachers need to provide the necessary infrastructure to support the implementation of learning. Teachers need to prepare lesson plans and student worksheets. The learning model guidebook is used by the teacher as a guide to implement the learning model.

f. Component 6: Instructional and Complementary Impact

Instructional impact describes the direct learning outcomes obtained by students against the learning objectives. Critical thinking skills, scientific knowledge, science literacy, communication skills, and collaboration skills as the instructional impact of applying the SSID model. The complementary impact describes other learning outcomes obtained by students due to the complementary of a conducive learning atmosphere. The accompanying impact of the SSID learning model is interest and motivation to learn, curiosity, emotional reasoning, ethics, and morals.

Expert validation includes validation of the learning model and its tools and critical thinking skills instruments. The assessment process was conducted through FDG with Delphi technique. The Delphi technique was chosen because there is one agreement between experts without groupthink or domination of one expert (Linstone & Turoff, 1975). The product and its rating sheet were sent to all validators. Validators in parallel provided assessment and feedback on the developed product. The results of the product assessment are described as follows.

The feasibility of the SSID learning model is seen from the SSID learning model components including rational theory, syntax, social system, reaction principles, support system, instructional impact and complementary impact. The results of the expert assessment can be seen in **Table 3**.

Table 3. SSID Learning Model Validation Results

Aspect	Raters					Aiken's V	Description
	1	2	3	4	5		
Rational theory	1	1	1	1	1	1	Valid
Syntax	1	1	1	1	1	1	Valid
Social system	1	1	1	1	1	1	Valid
Reaction principles	1	1	1	1	1	1	Valid
Support system	1	1	1	1	1	1	Valid
Instructional impact and complementary impact	1	1	1	1	1	1	Valid
Average						1	Valid

Table 3 shows the results of the validation of the SSID learning model. The results show that the overall average is 1, so it is concluded that the SSID learning model is feasible and ready to be used in learning. An example of the SSID learning model book cover can be seen in **Figure 2**.

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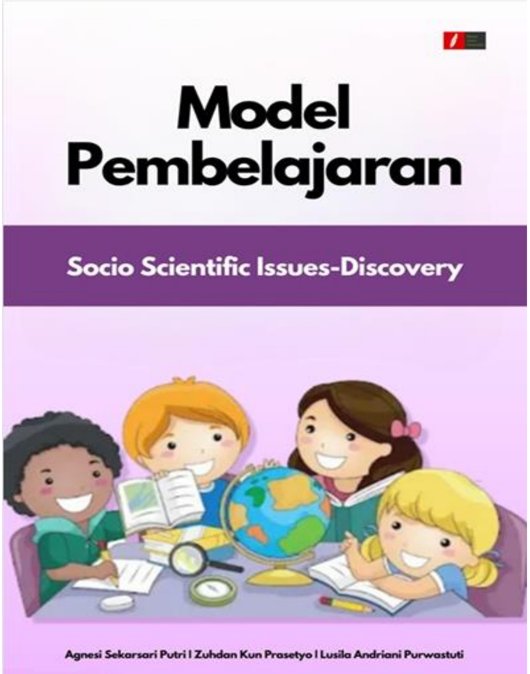

Figure 2. Cover of the SSID Learning Model Book

SSID learning model tools include teaching modules and student worksheets can be seen in **Table 4**.

Table 4. SSID Learning Model Learning Device Validation Results

Aspect	Raters					Aiken's V	Description
	1	2	3	4	5		
Learning model book	1	1	1	1	1	1	Valid
Learning model guide	1	1	1	1	1	1	Valid
Syllabus	1	1	1	1	1	1	Valid
Lesson plan	1	1	1	1	1	1	Valid
Student worksheet	1	1	1	1	1	1	Valid
Average						1	Valid

Table 4 shows the results of the SSID learning model device validation. The overall average is 1, so it is concluded that the SSID learning model device is feasible and ready for use in learning.

Students' critical thinking skills are measured using pretest (before learning begins) and posttest (after learning using the SSID learning model) questions. The number of questions used is five. The results of the expert assessment can be seen in **Table 5**.

Table 5. Critical Thinking Skills Test Validation Results

Items	Raters					Aiken's V	Description
	1	2	3	4	5		
1	4	3	4	4	4	0.92	Valid
2	4	4	3	4	4	0.92	Valid
3	4	4	4	4	4	1	Valid
4	4	4	4	4	3	0.92	Valid
5	3	4	4	4	4	0.92	Valid

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Table 5 shows the results of critical thinking skills validation. The results show that each item is in the range of 0.92 to 1, so it is concluded that the critical thinking skills test questions are feasible and ready to be used in learning.

The practicality of the SSID learning model was assessed based on a practicality questionnaire by five practitioners/teachers. The results of the practicality of the SSID learning model can be seen in **Table 6**.

Table 6. Practicality Test Results of the SSID Learning Model

Aspect	Raters					Aiken's V	Description
	1	2	3	4	5		
Syntax	1	1	1	1	1	1	Practice
Social system	1	1	1	1	1	1	Practice
Reaction principles	1	1	1	1	1	1	Practice
Support system	1	1	1	1	1	1	Practice
Instructional impact and complementary impact	1	1	1	1	1	1	Practice
Average						1	Practice

Table 6 shows the results of the practicality of the SSID learning model. The results show that the overall average is 1, so it is concluded that the SSID learning model is practical and useful to use in learning.

3.2. Discussion

The purpose of this research is to develop an SSID learning model through a literature review which then produces a learning model with components including rational theory, syntax, social system, reaction principles, support system, instructional impact, and accompanying impact. The learning model has been validated by five expert lecturers and five teachers. The results of the validation of the learning model were declared valid. The results of the practicality test conducted by teachers showed practical results to be applied in learning. This study makes a significant contribution to addressing the issue of low critical thinking skills among students, which has been reported in various previous studies, such as Fuad et al. (2017); Fauzi (2019); Ridho et al. (2019); Suryani et al. (2020); Arti dan Ikhsan (2020); Saputri et al. (2019); Patonah et al. (2021); and Astuti et al. (2020). However, most of these studies have focused solely on measuring critical thinking skills or the use of specific models in isolation, without developing new learning models that conceptually integrate scientific and social approaches. A gap that has not been adequately addressed in previous research is the absence of a learning model design that explicitly combines the strengths of discovery learning in scientific inquiry with a socio-scientific issues approach that emphasizes ethical and socially contextual critical thinking. This is what distinguishes and constitutes the main contribution of this research.

The feasible assessment given by the experts to the SSID learning model is based on their understanding of the needs, objectives, and belief that the learning model is potentially effective in improving critical thinking skills. The experts also assessed that the components in the SSID learning model are in line with the elements of the learning model as proposed by Joyce et al. (2015). In addition, science teachers assessed that the syntax of the SSID learning model is easy to implement in learning and they showed interest in using it.

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One of the advantages of the SSID learning model lies in its student-centered approach, with the teacher acting as a facilitator and collaborator. This approach is in line with constructivist learning theory that emphasizes students' active role in constructing their knowledge. In addition, the syntax of the SSID learning model is designed in the form of interesting activities and aims to develop students' critical thinking skills. In the learning process, students engage in group work and discuss collaboratively by respecting and valuing other opinions.

The SSID learning model can explicitly develop students' critical thinking skills through the application of the SSID learning model syntax. Learning begins by presenting a problem faced by students. Wang et al. (2018) explained that real problems presented can train students to construct knowledge and build meaningful understanding. Critical thinking skills can be trained by presenting real problems in everyday life to students (Zhou & Brown, 2017). Bowen and Shume (2020) argue that developing communication skills in students requires lessons designed by connecting real problems.

In the second learning stage, students identify the core of the problem presented. The activity of identifying problems is useful so that students are trained to know exactly what problems occur (Hew & Cheung, 2014), how to conduct investigations to find the right information (Wu et al., 2013), and what solutions can be done to overcome these problems (Hwang et al., 2015). Students who are trained to identify and understand problem patterns will be accustomed to choosing the best way to make problem-solving solutions (Atabaki et al., 2015).

Students are also invited to search and collect information to solve problems. Students conduct literature studies from various sources according to the themes they study by utilizing the internet and cell phones. Jackson (2014) explains that technology makes it easier for students to find information and add literature so that it can support smooth communication. Students share information in small groups to highlight complexities and share perspectives such as economic, social, and health aspects. The interaction of the social environment allows students to interact with each other to exchange ideas and collaborate in solving the problems presented (Öhman & Öhman, 2013).

Students make presentations followed by making conclusions. These discussion and presentation activities train students to communicate well (Lederman, 2012). Discussion and presentation activities train students to have the courage to convey ideas (Wood & Hartshorne, 2017), present material systematically (Wilkins et al., 2015). Students are also trained to be able to respect people who are speaking (Morreale et al., 2014). In the next stage of learning, students conduct group discussions to find solutions by considering various perspectives such as environmental, health, and community aspects. In addition, students also consider moral and ethical aspects. Ozturk and Yilmaz-Tuzun (2017) explained that the activity of analyzing solutions by considering various aspects of sciences can train students to develop critical thinking skills.

In the last stage, students analyze the advantages and disadvantages of the solutions made and determine the best solution to solve the problem by considering morals and ethics. Mashaza (2017) explains that students who are trained to construct thoughts logically and reconsider the results of thinking well will improve their critical thinking skills. At the end of learning, students make a reflection on the learning process which includes important things obtained after learning the material, interesting parts of learning, difficulties experienced in learning the material, and effective strategies used in learning the material. Reflection of learning for students to channel the expression of the learning

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process that has been done, whether it is good or still lacking. This can train students' confidence to express their opinions.

The SSID learning model can run well if teachers pay attention to the characteristics of each student in the class so that the division of discussion groups can run effectively and efficiently. Competent/excellent students can be divided evenly in each group which functions as scaffolding to guide other students to solve problems on their own. Teachers need to pay attention to the allocation of learning time so that learning activities can run optimally, for example by giving students a time limit for discussion and presentation.

4. CONCLUSION

The SSID learning model is a learning that presents scientific social problems designed so that students are actively involved in analyzing and solving problems by considering morals and ethics in order to discover new knowledge. SSID learning model components include rational theory, syntax, social system, reaction principle, support system, instructional impact and accompanying impact. Each component of the SSID learning model has different characteristics from other learning models.

The components of the SSID learning model and its tools have been validated by expert lecturers and teachers. The results of the validation of the SSID learning model components and their devices show that all are feasible and practical to use in learning. Meanwhile, the results of the validation of the critical thinking skills test instrument show that each item is valid for use in learning.

This study still has limitations, namely that it has not been widely tested at various levels of education, including testing in inclusive schools. Therefore, teachers who will apply the SSID learning model must understand each component of the SSID learning model. Teachers also need to prepare themselves if there are differences of opinion among students. The SSID learning model needs to be tested to test its effectiveness in improving critical thinking skills. Trials need to be conducted at various school levels.

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