

Research team-based learning: A new model for empowering students' research skills

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Abstract: Students' research skills still need to be empowered. The Research-Based Learning (RBL) model is reported to improve students' research skills, but it has weaknesses that need to be addressed. The Team-Based Learning model can accommodate the weaknesses of the RBL model and vice versa. The RBL and TBL models have advantages and disadvantages that complement each other. Therefore, this study aims to integrate the RBL and TBL models into a model that is expected to empower students' research skills. This study also ensures the model's validity, practicality, and effectiveness in empowering students' research skills by using validation sheets, observation sheets, response questionnaires, and student research skills questionnaires. The Plomp & Nieveen development model is used in this study. The developed model was tested on 40 students who had taken Environmental Science courses at the University of Riau. The findings show that the developed RTBL model with the stages of Preparing, Assessing Readiness, Researching in a Team, and Reflecting is valid based on the validator's assessment. The RTBL model is also practical and effective in improving research skills. The RTBL model developed can empower research skills and can be used by educators in the learning process.

Keywords: learning model; research team-based learning; research skills

1. Introduction

Research skills are skills that students must develop to create and socialize a product and scientific thinking of students (George-Reyes et al., 2023). Developing research skills is essential in preparing graduates to successfully face the demands of scientific and technological advances (Zlatkin-Troitschanskaia, 2021). Students must develop scientific knowledge and improve related skills, including observation, reading, argumentation, problematize, and socialization (Castillo-Martínez & Ramírez-Montoya, 2021). Students are expected to have critical, scientific, and systematic traits that trigger the acquisition of knowledge from the methodological and theoretical foundations of research; in addition, students must have the ability to manage information adequately and be able to foster curiosity about a scientific discipline (Ain et al., 2019; George-Reyes et al., 2023).

The results of the study by Zapata et al., (2023) stated that students still have low research skills and difficulty conducting literature reviews and bibliographies. Torres (2018) said that students' research skills still need to be improved. Students still lack research knowledge and skills and are still passive in participating in research projects in learning (Ommering et al., 2020). Students find it difficult to achieve the maximum level of research skills (Mugabo et al., 2021). Hughes (2019) stated that students' research skills are still low due to low knowledge related to research methodology and lecturers' less than-optimal role in training students' research skills.

One of the causes of low student research skills is that the learning process has not emphasized the empowerment of research skills (Hughes, 2019). The application of learning models is an important aspect of supporting students' various potentials and skills. Learning that provides opportunities for students to conduct research or investi-

gations can empower research skills (Abbott, 2019; Carberry et al., 2021; Hughes, 2019; Lee et al., 2020; Willison & Buisman-Pijlman, 2016).

Researchers have attempted to develop learning to train students' research skills. Innovative learning models including Research-Based Learning (RBL) are considered useful in training students' research skills (Hegde & Karunasagar, 2021; Khumraksa & Burachat, 2022; Marcella & Samofalova, 2022; Nogales-Delgado et al., 2022; Noguez & Neri, 2019; Solovieva et al., 2022; Thiem et al., 2023; Walkington & Ommering, 2022), the application of the RBL model with various scaffolding can also train research skills (Anson, 2020; Bowyer & Akpinar, 2024; Malinovski et al., 2014; Marcella & Samofalova, 2022; Sopandi et al., 2019).

The RBL model is a learning model that integrates research activities into the learning process. RBL involves investigating problems using scientific methods and academic literature and analyzing and finding a conclusion (Brew & Saunders, 2020). The advantages of the RBL model are that it supports students in designing, experiencing, and implementing the entire research process (problem identification, literature review, observation, hypothesis formation, research design, data collection and analysis, results and discussion, report preparation) which aims to produce scientific findings (Wessels et al., 2021).

RBL is stated to have several advantages, as explained previously, but RBL has weaknesses that need to be addressed. According to Afdal and Spernes (2018) and Brew and Saunders (2020), some things need to be completed from the RBL learning model, namely the need for feedback or reflection. Reflection is carried out to confirm the data findings with the research activities and student skills achievements. In addition, Afdal and Spernes (2018) also said that RBL is a complex process that requires student readiness. In their research, Afdal and Spernes (2018) added that students find it difficult to carry out research activities alone and require team collaboration. Hoffmeister et al., (2020) said that research project activities carried out by students independently have low scientific community relevance and can only achieve small sample sizes. Therefore, it is recommended that this RBL learning process be carried out as a team so that another learning model can accommodate the weaknesses of the RBL model.

The learning model that can complement the weaknesses of the RBL model is Team-Based Learning (TBL). The TBL model has advantages, namely emphasizing the stages of student readiness, reflection activities, and team collaboration (Coyne et al., 2018; Remington et al., 2017; Rotgans et al., 2019). TBL provides an innovative approach to student-centered learning (Burgess et al., 2019). The principles of team-based learning include that groups must be formed and managed well, students must be responsible for their individual and group work, immediate feedback (reflection), and activities that require team interaction involvement (Michaelsen, 2014).

The TBL model has advantages that can accommodate the weaknesses of the RBL model, but the TBL model also has weaknesses. Remington et al. (2017), Espey (2018), and Christensen et al. (2019) stated that TBL must consider challenging activities and create an environment that emphasizes teaching skills and strategies to engage students more in experimental activities. Rotgans et al. (2019) said that in their experience researching TBL, they saw that at the application stage, the exercises given were considered less effective by students because the activities were less challenging. Therefore, another learning model is needed with challenging activities involving students in experimental activities. The shortcomings of the TBL model can be accommodated by the RBL model, which has challenging activity stages and involves students in experimental activities through research activities integrated into the learning process.

The RBL and TBL models are complementary learning models and are needed in the learning process to support the development of student skills. Some previous studies examined RBL interventions to promote scientific questioning skills and experimental skills (Khumraksa & Burachat, 2022), data-driven and RBL to train language skills and research communication skills (Marcella & Samofalova, 2022), RBL learning improves knowledge and research skills (Schröder et al., 2023; Thiem et al., 2023), systematic liter-

ature review as a digital collaborative research-like learning activity (Ryan et al., 2023). Implementing the RBL model is challenging for students and requires scaffolding and collaboration (Bowyer & Akpınar, 2024). Studies on how RBL plays a role in research skills still need strengthening. Therefore, this research develops a new learning model that integrates the RBL and TBL models to empower students' research skills where no publications have been found in this regard. This research aims to develop a Research Team-Based Learning (RTBL) model that is valid, practical, and effective in empowering research skills.

2. Materials and Methods

2.1 Research design

This type of research is Research & Development, namely the development of the Research Team Based Learning (RTBL) learning model in empowering research skills. The model's development refers to the Plomp and Nieveen model (Plomp & Nieveen, 2013). The Plomp and Nieveen development model consists of three stages: 1) The preliminary research phase aims to observe the ongoing learning conditions, including needs and context analysis, literature review, and determination of performance criteria and the desired results. 2) The development/prototyping phase is carried out based on the results obtained in the previous stage, namely the preliminary research stage. The Prototyping or product development stage consists of designing learning models and formative evaluation. The formative evaluation stage refers to Tessmer's formative evaluation (Plomp & Nieveen, 2013), namely, self-evaluation, expert review, one-to-one, small group, and field test. 3) The assessment phase is a trial to assess the developed model's validity, practicality, and effectiveness. The research design used in this study to assess the effectiveness of the developed RTBL model is a one-group pretest-posttest design—tests at the beginning and end of learning in one group.

2.2 Population and samples

This study's population was all Riau University students. The sample consisted of 40 students who took environmental science and disaster mitigation courses.

2.3 Research design

The instruments used in this study consisted of an RTBL model validation sheet to assess the validity of the product, an RTBL model implementation observation sheet and, a student response questionnaire to learning to assess the practicality of the product, and a student research skills questionnaire to assess the effectiveness of the product. The validation sheet of the developed learning model aims to assess aspects of learning theories underlying the model, structure, syntax, reaction principles, social systems, support systems, instructional and accompanying impacts, implementation, and evaluation of the developed learning model. The RTBL model implementation observation sheet aims to assess aspects of the implementation of each stage in the RTBL model, namely the Preparing, Assessing Readiness, Researching in a Team, and Reflecting stages. The student response questionnaire assesses ease in following RTBL learning, attention, relevance, confidence, and satisfaction.

2.4 Research design

Qualitative data obtained at the preliminary research stage were analyzed descriptively. The data were on the ongoing learning process related to student's research skills and collaboration skills and the needs of the model being developed. The quantitative data obtained were calculated based on students' achievement scores for each variable using formula (1). Furthermore, the validation results of the expert model were tested for validity and reliability, the product validity criteria (Formula (2) and Table 1) and the interpretation criteria for the intra-class correlation coefficient (Table 2) were examined.

$$P = \frac{SC}{SM} \times 100 \tag{1}$$

Information:

P = Achievement

SC = Achievement Score

SM = Maximum Score

$$\text{Expert scoring} = \frac{\text{Total Score obtained} \times 100}{\text{Max score} \times \text{number of assessment aspects}} \tag{2}$$

Table 1. Product validity criteria

No	Average answer score	Validity level
1	90%≥	Very valid, can be used without revision *
2	75%-<90%	Valid, can be used with minor revisions
3	65% - < 75%	Quite valid, can be used with major revision
4	55%-<65%	Less valid, recommended not to use
5	<55%	Invalid, cannot be used

(* specifically for content material, the validity level must be 100%)

Source: Adapted from [Tegeh et al. \(2014\)](#)

Measure the consistency and reliability of the RTBL model assessment by the validator using inter-rater reliability (IRR). Inter-rater Reliability is reliability seen from the level of agreement between raters. Inter-rater reliability will provide an overview (in the form of a score) of the extent to which experts give the consensus or agreement/approval level. The IRR coefficient is the inter-class correlation coefficient (Intra-class Correlation Coefficients, ICC). Data were analyzed using the SPSS 23 for Windows program.

Table 2. Interpretation criteria for Intra-Class Correlation Coefficient (ICC)

ICC Value	Interpretation
>0.90	Excellent
0.75-0.90	Good
0.50-0.74	Moderate
<0.50	Poor

Source: adapted from [Portney \(2020\)](#)

Note: Acceptable reliability is at least in the good category

The implementation sheet of the RTBL learning model components and student responses are calculated using a scoring formula (3), then the criteria for product practicality are viewed ([Table 3](#)).

$$\text{Scoring} = \frac{\text{Total Score obtained} \times 100}{\text{Max score} \times \text{number of assessment aspects}} \tag{3}$$

Table 3. Product practicality criteria

No	Average answer score	Level of practicality
1	90%≥	Very practical
2	75%-<90%	Practical
3	65% - < 75%	Quite Practical
4	55%-<65%	Less practical
5	<55%	Not Practical

Source: Adapted from [Tegeh et al. \(2014\)](#)

Inferential analysis tests the effect of learning models on research skill variables. Data were analyzed using a paired sample t-test. Prerequisite tests, including normality and homogeneity test, precede paired sample t-tests.

3. Results

The research results are described according to the stages of research development of the Plomp development model, namely: (1) Preliminary Research, (2) Prototyping Phase, and (3) Assessment Phase.

3.1 Preliminary research

At the preliminary research stage, an initial study was conducted related to learning in the Environmental Science course, conducting a literature review on the research focus and determining the performance criteria to be achieved. Based on the results of an initial study of biology education students at three universities in Riau, namely Riau University, Riau Islamic University, and Lancang Kuning University, it was found that the average percentage of research skills was 64.27% in the poor category.

Based on a survey conducted on six lecturers who teach Environmental Science courses at 3 Universities in Riau, namely Riau University, Riau Islamic University, and Lancang Kuning University, a questionnaire showed that developing students' research skills is necessary. Research skills need to be developed with an average percentage of 96.67%. The results of the questionnaire and analysis of the Semester Learning Plan (RPS) documents show that the learning forms that lecturers often carry out are discussions, presentations, assignments, and lectures. Only a small portion of students use problem-based learning and project-based learning models. The learning and assessment processes have not emphasized the empowerment of students' research skills.

A literature review related to learning theories was conducted so that this RTBL learning model could be developed. Various learning theories have been studied, including constructivism, cognitivism, behaviourism, transformative, and experiential learning. In addition, literature studies that support the development of the RTBL model include the Higher Education curriculum and the Indonesian National Qualification Framework, learning models, and relevant previous research results.

3.2 Prototyping phase

The RTBL learning model developed consists of the following stages: 1) Preparing, 2) Assessing Readiness, 3) Researching in a Team, 4) Reflecting (Figure 1). Descriptions of activities for each stage in the RTBL model are also designed (Table 4).

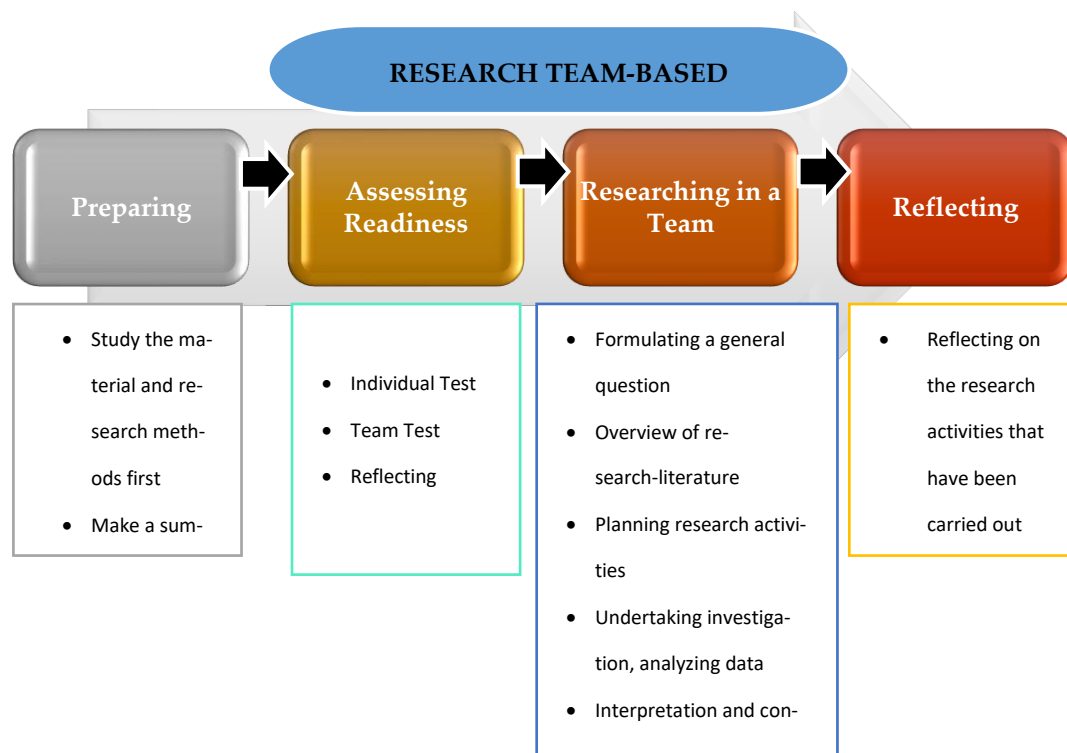


Figure 1. Stages and activities of the RTBL model

Table 4. Stages of the RTBL learning model

Stage	Learning Activities	
	Lecturer Activities	Student Activities
Preparing	<ul style="list-style-type: none"> • Ask students to study the material and research methods first • Ask students to make a summary of the material they have studied. 	<ul style="list-style-type: none"> • Study the research materials and methods first • Make a summary of the material that has been studied
Assessing Readiness	<ul style="list-style-type: none"> • Giving individual tests to students related to assigned learning material • Organize students into groups consisting of 3-5 group members. • Giving tests in groups • Provide <i>feedback</i> on the results obtained by the group 	<ul style="list-style-type: none"> • Answer individual tests given by the lecturer • Students form groups consisting of 3-5 group members. • Answering the test in groups • Respond to <i>feedback</i> given by lecturers
Researching in a Team	<ul style="list-style-type: none"> • Explaining problems that exist around and are close to students' lives so that the problems studied are contextual as • Ask students to conduct a 	<ul style="list-style-type: none"> • Create research questions from problems given in groups • Conduct a literature review or literature review related to re-search that will be carried out in groups

Stage	Learning Activities	
	Lecturer Activities	Student Activities
	literature review related to the research that will be carried out in groups. <ul style="list-style-type: none"> • Ask students to make a research plan that will be carried out in groups and check the research plan made by the group. • Ask students to conduct investigations (go to the field) and analyze data in groups, and the lecturer will guide the groups in analyzing the data. • Ask students to interpret data and research results in groups • Ask students to make reports, present them in groups, and provide feedback on the group results. 	<ul style="list-style-type: none"> • Make a research plan that will be carried out in groups • Conduct investigations and analyze data in groups • Conducting data interpretation and research results in groups • Make reports and present them in groups
Reflecting	<ul style="list-style-type: none"> • Provide feedback on the research results of each group • Ask students to reflect on the research activities they have carried out 	<ul style="list-style-type: none"> • Responding to feedback given by lecturers and reflecting on research activities that have been carried out • Create a reflective essay on research activities that have been carried out with the group

3.3 Preliminary research

The formative evaluation stage refers to Tessmer's formative evaluation (Plomp, 2013), namely:

3.3.1 Self-evaluation results

The results obtained at this stage are model books and research instruments that the researcher has independently checked. Some things that are based on the results of the self-evaluation are correcting writing or typing errors and improving tables titles and the format of the products that have been developed.

3.3.2 Expert review results

The results obtained at this stage are the validity value of the RTBL model (Table 5). The RTBL learning model has been designed and developed as a model book validated by three learning strategy experts and one practitioner.

Table 5. RTBL model validity results

No	Assessment Aspects	Validators				Average
		1	2	3	4	
1.	Learning theories	92	100	100	100	98
2.	Model structure	90	85	90	90	89
3.	Syntax	88	92	100	92	93
4.	Reaction principle	95	95	100	95	96
5.	Social system	90	95	95	90	93
6.	Support system	93	87	100	93	93
7.	Instructional and accompanying impact	95	90	100	100	96
8.	Implementation of learning	90	90	90	90	90
9.	Evaluation	100	100	100	100	100
Average		93	93	97	94	94

The average percentage result of the expert agreement level was 94%, which is in the very valid category (Table 5). The reliability value between validators of 0.845 (Table 6) shows that experts' consensus or agreement/approval is in a good category (Portney, 2020).

3.3.3 Results of one-to-one and small-group evaluations

One-to-one trial is then carried out. It aims to identify product clarity, direction clarity, completeness, difficulty level, errors, and grammar. Individual evaluations were conducted on three students with different abilities: one high-ability student, one medium-ability student, and one low-ability student. Students provided comments and suggestions (Table 7). After that, the small group evaluation stage was continued. Small group evaluation consists of 9 students with different ability levels: three in the high group, 3 in the medium group, and 3 in the low group. In the small group trial, students simulated the RTBL model. Furthermore, students provided comments and suggestions, and improvements were made to implementing the RTBL model simulation (Table 7).

Table 6. Intra-class correlation coefficient (ICC)

Intra-class Correlation Coefficient							
	Intra-class Correlation ^b	95% Confidence Interval		F Test with True Value 0			
		Lower Bound	Upper Bound	Value	df1	df2	Sig
Average Measures	.845	.743	.912	7,029	37	111	.000

Table 7. Results of one-to-one and small-group evaluations

No	Things to improve	Repair
One-to-one evaluation		
1.	Some sentences need to be clarified to make them easier to understand.	Improvements have been made to words that are difficult for students to understand.
Small group evaluation		
1.	Instructions for student activities need to be made more detailed so that students can better carry out activities in the RTBL model.	Improvements have been made by creating more detailed student activity instructions.
2.	In the research plan preparation section, it is necessary to provide points that students must write.	Improvements have been made by providing important points that students must write, including determining the method, research samples/respondents, research location, data collection and analysis techniques, and research instruments.

3.3.4 Field test evaluation results

Small group evaluation will then be conducted at the field test stage. Field tests were conducted to see the practicality and effectiveness of the developed learning model. Based on the results of the model trial observations, it is known that all syntax of the learning model can be implemented well by lecturers and students. The criteria for practicality are seen from implementing the RTBL model as seen from the activities of lecturers and students (Table 8) and student responses to the RTBL model (Table 9).

The average implementation of the RTBL learning model based on lecturer activities obtained a value of 99.5% with very practical criteria. The average implementation of the RTBL learning model is reviewed from student activities with a value of 97.5% and very practical criteria. The results of observations on implementing the RTBL model show that all syntax can be implemented well and that the developed model is very practical.

Table 8. The average value of the results of observations on the implementation of the RTBL Model

Learning stages	Lecturer activity		Student activity ob-	
	observation value (%)	Criteria	servation value (%)	Criteria
Stage 1: <i>Prepar-</i> <i>ing</i>	100	Very Practical	100	Very Practical
Stage 2: <i>Assessing Read-</i> <i>iness</i>	98	Very Practical	98.3	Very Practical
Stage 3: <i>Researching in a</i> <i>Team</i>	100	Very Practical	98.1	Very Practical
Step 4: <i>Reflecting</i>	100	Very Practical	93.4	Very Practical
Average	99.5	Very Prac- tical	97.5	Very Practical

Table 9. Student responses to the implementation of the RTBL model

No	Assessment Aspects	Mark	Criteria
1.	Ease of following RTBL learning	89.5	Positive
2.	Attention	85.1	Positive
3.	Relevance	87.8	Positive
4.	Confidence	86.8	Positive
5.	Satisfaction	88.8	Positive
Average		87.6	Positive

The average result of student responses to the implementation of the RTBL model obtained a value of 87.6%, indicating a positive category. This finding shows that students respond positively to the RTBL model in environmental science courses. The results of the practicality test showed that the RTBL model is practical for lecturers and students. Therefore, the assessment of the RTBL model can be continued at the effectiveness test stage to empower students' research skills.

The effectiveness criteria are seen from the inferential analysis used to test the influence of the learning model on research skills variables. First, the normality and homogeneity of the initial and final student skills questionnaire scores were analyzed (Table 10).

Table 10. Results of the research skills prerequisite test

Variable	Value	Interpretation
Normality of initial research skills	0.103	Normal
Normality of final research skills	0.200	Normal
Homogeneity	0.181	Homogeneous

The results of the paired sample t-test showed that the initial research skill scores were significantly different from the final research skill scores of students with a sign value of 0.000 (sign. < 0.05). This shows that the RTBL model affects research skills. The average value of students' research skills after using the RTBL model is higher than the average value of students' research skills before using the RTBL model (Figure 2).

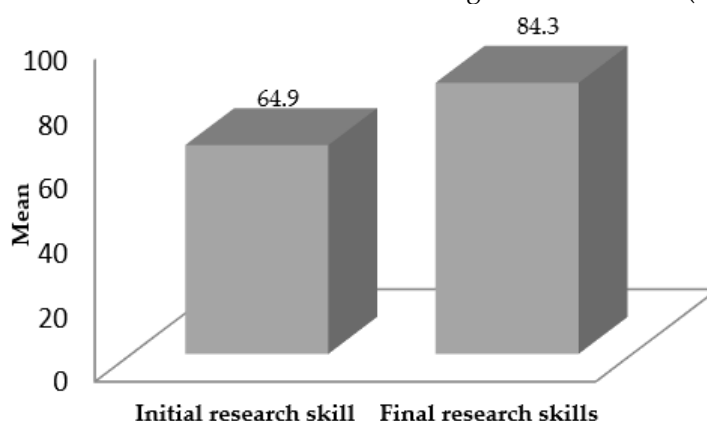


Figure 2. Graph of mean values of students' initial and final research skills

4. Discussion

4.1 Preliminary research

The low research skills of students in the initial study were due to the learning process carried out so far not systematically developing students' research skills and the lack of access to relevant learning activities to develop research knowledge and skills (Tajuria et al., 2024). Based on the initial study's results, the learning process is quite diverse, in-

cluding lectures, discussions, presentations, and assignments. However, applying these methods has not generally empowered students' research skills. The learning process carried out has not provided students with the opportunity to conduct research or investigations that can empower research skills. These research skills can be developed by emphasizing learning that provides opportunities to be involved in research or investigation activities (Abbott, 2019; Carberry et al., 2021; Hughes, 2019; Lee et al., 2020; Willison & Buisman-Pijlman, 2016). Students have not been trained in designing, experiencing, and implementing the research process (problem identification, literature review, hypothesis formation, research design, data collection and analysis, results and discussion, and report preparation), which aims to produce scientific findings. The learning process carried out is still focused on finding information and presenting that information.

A literature review is conducted to collect information and examine theories to develop a learning model, such as theories that underlie learning models that are relevant to the learning process and can empower research skills. A literature study is conducted by analyzing studies of learning theories, books, and research articles related to the focus of the research. All literature reviews are used to develop the RTBL learning model. The construction of the learning model developed is related to 1) syntax, 2) social system, 3) reaction principle, 4) support system, and 5) instructional and accompanying impact (Joyce et al., 2015).

4.2 Prototyping research

Research Team-Based Learning (RTBL) model consists of the stages of Preparing, Assessing Readiness, Researching in a Team, and Reflecting. The development of this RTBL model is based on several learning theories, including constructivism, cognitivism, behaviorism, transformative learning, and experiential learning (Figure 3). Based on the study related to constructivism learning theory, the Preparing stage was developed, which is the initial stage in the RTBL model. In addition, the Preparing stage in the RTBL model that was developed is also based on Ausubel's learning theory.

According to Jean Piaget, constructivism theory emphasizes learning as the construction of knowledge by individuals. Students are given the responsibility to build their understanding through independent preparation and activity (Dong et al., 2021). According to Vygotsky, social constructivism theory emphasizes that learning outcomes can be effective when students actively build their own understanding through social engagement with peers. They are encouraged to provide answers and test new theories (Do et al., 2023). According to social constructivism-based theory, learning is a process in which individual knowledge and understanding develop through supportive interactions with peers in a shared group, understanding-building learning, or collaboration (Männistö et al., 2020).

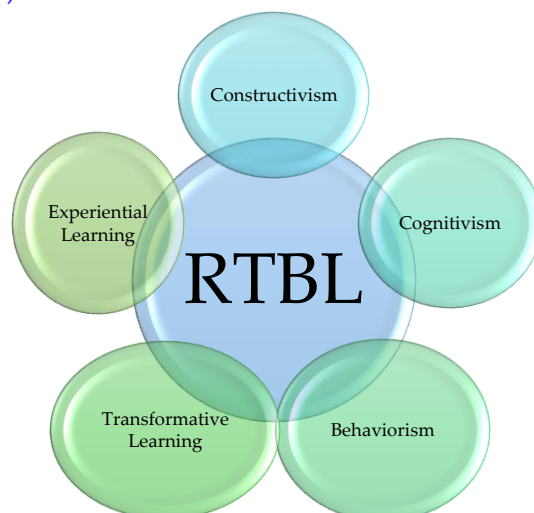


Figure 3. Learning theory underlying the RTBL model

Ausubel's theory states that meaningful learning is a process in which new information is linked to relevant concepts in a person's cognitive structure. Students' initial concept regarding the concept to be learned is very important to help students instill new knowledge from material and solve problems (Zhao, 2023). According to Ausubel, cognitive theory is that meaningful learning can be obtained by linking concepts related to situations in the surrounding environment. Real situations can make the learning experience more meaningful (Al-Jarrah et al., 2018). According to Bandura, social cognitive theory, personal cognition, behavior, and environment are three factors that interact dynamically. This offers a useful perspective for understanding how people can change or adjust their behavior by examining how personal and environmental factors affect user persistence (El-Bassiouny & El-Naggar, 2023; Schunk & DiBenedetto, 2020).

Based on the theory of social cognitive and behaviorism, the stages of Assessing Readiness in the RTBL model are developed, consisting of Individual Test, which is giving individual tests to students that aim to hold students accountable for their preparation, and Team Test, which is giving group tests to students that allow students to evaluate and discuss their answers in groups so that interactions will be formed, both starting from personal cognition, personal behavior and the environment in the group. Behaviorist learning theory prioritizes small elements and parts, is mechanistic, emphasizes the role of the environment, emphasizes the formation of reactions or responses, emphasizes the importance of practice, emphasizes the mechanism of learning outcomes, and emphasizes the role of ability, and the learning outcomes or responses obtained are the desired behavior (Manolescu, 2013).

The RTBL learning model uses cognitive learning theory, constructivism, and experiential learning through the stages of Researching in a Team, the implementation of research that raises real problems, and students solving existing problems through direct research activities to make students' learning experiences more meaningful and group collaboration. Experiential learning theory emphasizes that learners are directly involved in an experience or activity. This experience can come from real situations or simulations (Kolb, 2014). Experiential learning theory states that knowledge is generated from experience through a learning cycle driven by a double dialectic resolution, namely action/reflection and experience/abstraction (Passarelli & Kolb, 2012).

Based on the transformative learning theory, the Reflecting stage was developed in the RTBL model. The theory of transformative learning, according to Jack Mezirow, argues that individuals must think critically about their own experiences. This, in turn, leads to a transformation of perspective. Students can only develop meaning structures if they reflect on their learning behavior. This process of reflection increases their self-awareness and facilitates self-understanding at a deeper level (Kitchenham, 2008). Transformative learning is learning that changes problematic frames of reference to make them more inclusive, discriminatory, reflective, open, and emotionally transformative (Mezirow & Taylor, 2009).

4.3 Assessment phase

The RTBL learning model has been categorized as a good learning model. This is based on the validation results by experts who stated that the RTBL model is valid and worthy of being implemented in the learning process, as well as the results of its reliability. The quality of the learning model in educational design research is determined by internal relevance and consistency aspects (Haviz, 2018). The RTBL model validation assessment includes nine components: learning theory, model structure, learning syntax, reaction principles, social systems, support systems, instructional and accompanying impacts, learning implementation, and evaluation. Based on the assessment of the learning theory underlying the development of the RTBL model, it obtained a value in the very valid category. The RTBL model is theoretically based on learning theories, including constructivism theory, cognitivism theory, behaviorism theory, transformative learning theory, and experiential learning theory. The validation results of the syntax aspect of the RTBL model obtained a value in the very valid category. Learning syntax is

declared valid with a clear purpose. The RTBL model has a clear purpose in empowering research skills. High validity scores indicate high consistency (Bakar et al., 2024). This indicates that the product developed has met the set targets (Souza et al., 2017). The RTBL model is valid if it meets the needs and is supported by relevant theories and consistency between components (Plomp & Nieveen, 2013).

The results of the analysis of the RTBL model implementation observation and student response questionnaires show that students and lecturers can easily implement the RTBL model and get a positive response from students. A product is practical if the developed product can be used easily and according to the developer's intentions (Plomp & Nieveen, 2013). The RTBL model is a model developed to empower students' research skills. Each stage in the RTBL model makes it easier for lecturers to develop students' research skills. The Preparing stage will help students prepare themselves to take part in learning. The importance of student preparation so that students work more effectively in learning (Branney & Priego-Hernández, 2018; Christensen et al., 2019). The Assessing Readiness stage will ensure that students master the concept of the material. The existence of a readiness assurance test makes students more motivated to learn and creates a dynamic learning environment (Burgess et al., 2018; Christensen et al., 2019). Researching in a Team stage allows students to collaborate when conducting research. Student activities working collaboratively on group projects can make it easier for them and provide evidence of learning progress (Daryanes, 2021; Daryanes & Sayuti, 2023; Hegde & Karunasagar, 2021; Marín, 2020). The Reflecting stage makes students aware of their mistakes and improves research activities. Reflection activities allow students to improve and enhance their performance in the future (Christensen et al., 2019; Clark et al., 2018).

The effectiveness test results show that students' research skills increased after learning with the RTBL model. The RTBL model is a research-based learning model emphasizing the preparation stage, collaboration, group research, and reflection. Each stage in the RTBL model can train students' research skills. Learning that integrates research into the learning process will improve students' research skills (Abbott, 2019; Bastiaens et al., 2017; Carberry et al., 2021; Hoffmeister et al., 2020; Hughes, 2019; Lee et al., 2020). Students can improve their resource management skills through their experience in organizing research activities (Noguez & Neri, 2019; Sota & Peltzer, 2017). The RTBL model provides real problems for students to then develop research questions from these problems and determine how to find the right solution. Learning that places students in real problems and situations where they apply scientific methods to find solutions to existing problems can improve students' research skills through the inquiry process (Brew & Saunders, 2020). Essential learning involving investigating problems using scientific methods and academic literature and integrating research into learning can develop scientific skills (Brew & Saunders, 2020; Daryanes & Sayuti, 2023). The RTBL model also emphasizes preparation and reflection activities. The preparation stage is carried out so that all students have adequate knowledge to conduct research. This is important because research activities in learning are complex activities that require student readiness (Afdal & Spernes, 2018). Reflection is carried out to confirm the data findings with the research activities and student skills achievements. Emphasizing reflection activities can improve students' research skills (Hughes, 2019). Collaborative activities in the RTBL model contribute to improving students' research skills. Students must learn to work together with lecturers, fellow students, and the community in academic activities to train students' research skills (Brew & Saunders, 2020).

This research is still being conducted at one university, using a limited sample. To increase the validity of the results of this study, it is necessary to try it out in more universities and increase the sample size. More specifically, this research was conducted on one specific course, environmental science.

5. Conclusions

The RTBL model consisted of four stages: Preparing, Assessing Readiness, Researching in a Team, and Reflecting. The development of the RTBL model is based on

constructivist, cognitivist, behaviorist, transformative, and experiential learning theories. The RTBL model that has been developed has been declared valid and reliable theoretically and empirically so that it can be used in the learning process. The RTBL model has also been said to be practical based on the results of observations of lecturer and student activities in implementing all stages of the RTBL model and based on the responses of students who have implemented the RTBL model. In addition, the RTBL model is also said to be effective in empowering students' research skills.

The RTBL model can be recommended to be formally integrated into the college curriculum. The RTBL model can be an alternative and effective learning model to empower students' research skills. Further research should consider increasing the number of research samples. The RTBL model can be applied in various relevant study programs or disciplines to determine its effectiveness for various groups of students. It is also useful to know whether the model can be applied outside the scope of a particular study.

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