p-ISSN: 2621-3761 | e-ISSN: 2621-2889
DOI: 10.12928/irip.v5i2.6488

Build Students' Research Skills Through Collaborative Real-World Analysis-Based Learning

Arini Rosa Sinensis[1]*, Thoha Firdaus[2], and Butch O Saulon[3]
[1,2] Department of Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Nurul Huda, Indonesia
[3] School of Graduate Studies, University of Nueva Caceres, Philippines
Email: arini@unuha.ac.id

Article Info

Article History
Received: Aug 19, 2022
Revision: Dec 29, 2022
Accepted: Dec 29, 2022

Keywords:
Collaborative research
Rasch modeling
Research skills
Wright map

ABSTRACT

Research skills are one of the skills that need to be built for students to face the challenges of the 21st Century. Therefore, this study aims to build research skills through the Collaborative Real-World Analysis (CReW-A) learning model. This study uses the One-Shot Case Study design. Respondents came from 21 Physics Education students who were grouped into seven research groups. Research skills were observed using a 5-point Likert rating scale observation sheet. Students research skills were analyzed using Rasch modeling, the Wright map technique combined with the Logit Value of Person (LVP). After applying the Collaborative Real World Analysis (CReW-A) learning model for four weeks, students' research skills were well-developed in most research groups. So, the Collaborative Real World Analysis (CReW-A) learning model that has been implemented has been able to build the research skills of physical education students. Therefore, in the future, students can use these skills to innovate to face the challenges of the 21st Century.

To cite this article:
A. R. Sinensis, T. Firdaus, and B. O. Saulon, "Building Student Research Skills Through Collaborative Real-World Analysis Based Learning," *Indones. Rev. Phys.*, vol. 5, no. 2, pp. 57–65, 2022, doi: 10.12928/irip.v5i2.6488.

I. Introduction

Today's 21st Century of Learning demands higher education to produce graduates with skills to support life in the future. These skills are socio-cultural, critical, and creative thinking skills in metacognition and problem-solving, communication and technology literacy to explore information, and productivity in organizing and conducting research effectively and efficiently [1]. Research skills help graduates to critically investigate problems, generate and evaluate relevant data, and test ideas, theories, and hypotheses, which can be used to obtain information [2]. For prospective physics teacher students, skills in carrying out research are fundamental because it corresponds to the nature of physics itself, namely the scientific method.

In the early semester, physics teacher candidates at Universitas Nurul Huda take two practicum courses: fundamental physics and chemistry. These two courses provide students with the skills to conduct research through practicum activities in the laboratory. The physics experiment activities in the laboratory gave the impression of a Cookbook because students only followed the guidelines, student activity sheets, and available practicum guides. The cookbook type does not make students actively participate in discovering concepts because students only follow practicum procedures following the existing steps [3]. Efforts to overcome the weaknesses of the cookbook version of practicum can be made through practicum/research methods that invite students to recognize, observe and analyze real-world problems or phenomena through collaborative learning. This allows students to improve their abilities and research skills for the better.

Apart from regular lectures, this type of Student Creativity Program (PKM) also provides access for students to compile research proposals with several schemes, including PKM-Research and PKM Scientific Articles. Both schemes aim to hone students' research skills and lead to scientific publications. Research skills since the early semester have been given in the form of simple research activities related to various surrounding natural phenomena, either integrated within the course or outside the lecture. One of the goals is that prospective physics teachers can design physics research and carry it out with a suitable method and be able to apply science using technology by paying attention to the everyday environment [4].

The low research ability of prospective physics teacher students at Universitas Nurul Huda is increasingly visible when they take semesters 5-8, including 1) low ability to find problems, 2) inaccuracies in formulating problems, 3) inaccuracies in choosing research methods, 4) organizing research, 5) answering hypotheses and 6) lack of publication of research results. This ability is reflected in the final project, physics seminar courses, and other courses that require students to do research. In Indonesia, the low research skills of higher education students are reflected in several reports [5]–[8]. Students research skills in designing/designing experiments, formulating problems, and the accuracy of research methods still need to improve.

Research skills for students are essential skills [9]. This is because, in today's world of work, every individual must master research [10]. Through research, industry, companies, or institutions/agencies can develop businesses and findings that benefit society and their country. Research and innovation are essential parts of the development of science and technology. The foundation for research and technology development is to provide quality research skills to prospective researchers in the future. Universities can carry out this task as educational institutions that also act as centers for developing science and technology [7].

Students, as researchers, are active learners who emphasize research and investigation processes [11]. There needs to be more than just providing theories about scientific work to provide research provisions. Students need practice so that they have the skills to apply the scientific method. Research exercises are crucial for overcoming student learning problems [5]. Research skills are essential for students because science and technology continue to develop rapidly. By improving research skills, students will be better able to find and access relevant and accurate information, as well as analyze and evaluate this information critically. Research skills can also help students develop new ideas and solve problems creatively. Research skills also help students solve problems and find solutions to problems that exist in the real world.

In addition, research skills are also essential for students who will continue their postgraduate studies or work in fields that require research skills, such as researchers, academics, or professionals in technology or science. Thus, improving research skills is important for preparing students for future careers. Therefore, it is necessary to have a lesson that can build the skills of prospective physics teacher students. Learning models and strategies for the 21st Century need renewal that focuses on cooperative and collaborative learning to solve complex problems [12].

Some research on collaborative-based learning that is used in physics learning includes an exploratory assessment [13], a Collaborative Learning Annotation System [14], The Effect of Interaction in Collaborative Solving on speed problems [15], Collaborative learning innovations focus on inquiry, technology, and collaborative skills [16], Collaborative group learning in the introduction of physics learning [17], collaborative learning has a positive effect on overall attitudes and learning habits [18], Collaborative problem-solving based learning on thermodynamic learning for problem-solving and thinking skills reflective [19], Effect of Task-Based Collaborative Learning on Mathematical Physics Learning Outcomes [20] STEM-based online collaborative learning [21], Development of Collaborative Real World Analysis lectures for prospective physics teachers [22]. The usefulness of collaborative problem-solving utilizing decision-making tasks in improving physics teacher candidates' critical thinking skills [23] collaborative learning for metacognitive awareness [24]. The results of several research studies identified that collaborative learning had been implemented in physics learning, which focuses on improving higher-order thinking skills, attitudes, and learning innovations. However, innovation in physics learning that is integrated into direct observation activities, and real-world analysis in research activities that support the research skills of physics students has yet to be seen. This collaborative learning that follows the nature of physics and can be used to build research skills is Collaborative Real-World Analysis (CReW-A).

CRew-A is a learning model that aims to analyze the real world [22]. This learning model builds on collaborative learning, which is very important in the 21st Century. This learning occurs in dynamic and interdisciplinary teams, such as scientific teams. Collectively, students explore problems, explain and express ideas, argue, communicate, and reflect on knowledge [19]. Therefore, building the research skills of Physics Education students at Universitas Nurul Huda is very suitable for CRew-A learning because this learning can improve performance in the modern world through teamwork [25]. Collaborative learning supports student discussion and cooperation activities where they explain scientific phenomena and share knowledge through research (mini-research) [26].

Collaborative learning in physics lectures can help students understand complex concepts more effectively. For example, students can work together in groups to solve physics problems that require a deep understanding of different concepts. Collaborative learning can also help students understand how different concepts are interrelated and how they can work together to achieve set goals. Thus building students' research skills, it must be done from the start by designing learning that equips these skills, namely with CReW-A-based lectures. Therefore, this study aims to build students' research skills by applying the CReW-A learning model.

p-ISSN: 2621-3761
e-ISSN: 2621-2889

II. Theory

Research Skills

Research systematically gathers and analyzes information to increase understanding of the studied phenomenon. Research skills are needed in conducting research, including using tools, strategies, problem-solving skills, critical thinking, and disseminating research results [27]. Research is considered an essential part of education, especially science education at the high school and university levels [28]. Science research skills refer to applying procedural and declarative knowledge to create and conduct scientific experiments properly.

Basic research skills include observation, measuring, classification, communication, generating inferences, making predictions, and integrated skills like analyzing data, manipulating variables, developing operational definitions, formulating hypotheses, and carrying out experiments. In general, research abilities involve developing, implementing, and reporting on research findings [11].

The research skill indicator used in this study adopted the assessment of the research ability indicator from [29], which is shown in Table 1.

Collaborative Learning

The characteristics of collaborative and student-centered learning are one of the recommendations from [30] to be implemented in learning in higher education. These characteristics describe learning in the 21st Century. Therefore, collaborative learning integrated into a contextual approach (real-world situations) is suitable for application in higher education.

Collaborative problem-solving learning is an example of learning that is built on a constructivist approach [25], [31], [32]. Collaborative problem-solving stems from social constructivism, which emphasizes advancing knowledge through joint problem exploration, collaborative planning, and monitoring the problem-solving process to obtain better solutions [31]. This is due to its social and constructive nature. Collaborative problem-solving activities have become an instructional approach that facilitates the construction of scientific knowledge and increases students' understanding of scientific knowledge [33], [34].

Table 1. Research skill indicators

No	Indicators	Score	Criteria
1	• Formulate research objectives appropriately according to research topics/themes. • Using research methods appropriate to the research objectives. The methodology is described and refers to sources relevant to the research topic. • Identify and list some of the problems and sources of problems. • Analyze the information collected by making comprehensive conclusions as a result of the research conducted. • Provide four suggestions that can be implemented and followed up at the research site.	5	*Excellent*
2	• Formulate research objectives appropriately according to research topics/themes. • Using research methods appropriate to the research objectives. The methodology is described and refers to sources relevant to the research topic. • Mention some of the problems and sources of problems. • Analyzing the information collected by making comprehensive conclusions as a result of the research that was conducted, but some information was not conveyed. • Provide four suggestions that can be implemented and followed up at research sites.	4	*Good*
3	• Formulate research objectives but do not follow research topics/themes. • Using an information-gathering methodology that is inconsistent with the research objectives. The methods are not described. Referring to sources less relevant to the topic under study. • Mention some of the problems and sources of problems in a limited way. • Analyzing the information collected by making comprehensive conclusions as a result of the research that was conducted, but some information was not conveyed. • Provide three suggestions that can be implemented and followed up.	3	*Satisfactory*
4	• Formulate research objectives but do not follow research topics/themes. • The methodology used to collect information is not following the research objectives. The methods are not described. Referring to sources but not relevant to the topic/theme being researched. • Limited in mentioning several problems and sources of problems. • Not analyzing the information collected, only reporting findings. • Provide two suggestions that can be implemented and followed up at the research site.	2	*Weak*
5	• Formulating research objectives is not precise. • The methodology used to collect information is not following the research objectives. The methodology is not described. Referring to sources that are not relevant to the research theme • Not listing problems and sources of problems. • Did not analyze the information collected, and very few findings were reported. • Provide suggestions that cannot yet be implemented at the research site	1	*Very Weak*

Real World Learning helps students improve their understanding of problems (involving knowledge) and methodological competence in applying problem-solving approaches [35]. Real-World learning, if done collaboratively, will equip students with critical thinking to reflect and argue with their collaborating partners. In addition, students can apply problem-solving methods by analyzing problems systematically to provide alternative solutions through teamwork. Thus, the integration of Real-World Learning and Collaborative becomes a learning model following science and 21st Century learning characteristics.

Collaborative *Real World Analysis* (CReW-A)

Collaborative Real World Analysis (CReW-A) which has been developed by [36], is a future learning model that emphasizes the learning process of nature (real world) as a material object. The six stages of the CReW-A learning model sequentially are apperception, introduction, explanation, exercise, presentation, and reflection. The design characteristics of the CReW-A learning model are shown in Figure 1.

The six stages of the CReW-A learning model contain elements of 21st-century learning and are modified, as shown in Table 2.

III. Method

This research is a type of One-Shot Case Study [37], [38]. Respondents involved in this study came from 21 Physics Education students who took the Basic Physics Practicum 1 course. Before the lecture started, students were grouped into seven groups, each consisting of 3 people. The CReW-A (Collaborative Real-World Analysis) learning model builds students' research skills. The research was conducted in 4 meetings with the following topics: 1) Introduction to simple research, 2) Observation of phenomena in the surrounding environment related to physical phenomena, 3) Conducting research activities based on CReW-A, and 4) Reporting research results.

Research skills are assessed based on research reports produced by students. The scoring rubric uses a 5-point Likert rating scale. Research skills are evaluated based on five indicators, namely: 1) Problem identification, 2) Research objectives, 3) Research methods, 4) Analysis and conclusions, and 5) Suggestions and follow-up shown in Table 3.

Student research skills data were analyzed using the Rasch modeling of the Wright map technique combined with the Logit Value of Person (LVP) [39]. Rasch modeling is one model that transforms ordinal data derived from a Likert rating scale into an interval scale [40], [41]. The software used is Microsoft Excel and Winsteps 4.6.1 [42]. Microsoft Excel software was used to prepare raw data, and Winsteps 4.6.1 was used to analyze data using Rasch modeling.

IV. Results and Discussion

Collaborative Real-World Analysis (CReW-A) is a future learning model that emphasizes the learning process of nature (the real world) as a material object [36]. The CReW-A learning model's six important stages sequentially: apperception, introduction, explanation, practice, presentation, and reflection.

Figure 1. The design characteristics of the CReW-A

Table 2. Syntax of the CReW-A learning model

No	Syntax	Description
1	Apperception	The Apperception stage facilitates students to recall old material that has been studied and is related to the research that will be carried out.
2	Introduction	The introduction is the information exploration stage. Lecturers provide stimulus through various information so that students examine real-world phenomena. Then students write down a list of problems they encounter in the real world.
3	Explanation	The explanation is a debriefing stage for students about workflow in learning/research.
4	Exercise	The Exercise stage facilitates lecturers giving assignments to students to carry out mini-research related to real-world analysis and observations.
5	Presentations	At the Presentations stage, students show the results of their work or research from the real world. Each group shows the information and data they have collected.
6	Reflection	At the Reflection stage, the lecturer confirms to students what essential concepts they have learned.

Table 3. Research skills assessment rubric

No	Indicator	Criteria	Score
1	Identification of problems	Not registering a problem.	1
		Limited in mentioning a few problems.	2
		Mention several problems and limit to mentioning the source of the problem.	3
		Mention some of the problems and sources of problems.	4
		Identify and list some of the problems and sources of problems.	5
2	Research aims	Wrong research aims	1
		Develop research objectives but not follow the research topic/theme	2
		Develop research objectives but not follow research topics/themes	3
		Develop research objectives quite following the research topic/theme	4
		Develop research objectives appropriately according to research topics/themes	5
3	Research method	Wrong Research Methods	1
		The methodology used to collect information needs to follow the research objectives. The methods are not described. Referring to sources but not relevant to the topic under study	2
		The research method used follows the research objectives. The methods are not described. Referring to sources but not relevant to the topic under study	3
		The research method used follows the research objectives. The methods are described. Referring to sources but not relevant to the topic under study	4
		The research method used follows the research objectives. The methodology is described and refers to sources relevant to the research topic.	5
4	Analysis and Conclusion	Does not analyze the information collected.	1
		Does not analyze the information collected and only reports findings.	2
		Analyzing the information collected by making conclusions as a result of research conducted, but there is information that is not conveyed.	3
		Analyzing the information collected by making comprehensive conclusions as a result of research conducted, but there is information that is not conveyed.	4
		Analyze the information collected by making comprehensive conclusions as a result of the research conducted.	5
5	Suggestions and Follow Up	Not Providing advice and follow-up.	1
		Provide advice that can not be implemented in the research area	2
		Provide one suggestion that can be implemented and acted upon	3
		Provide two suggestions that can be implemented and followed up at the research site.	4
		Provide three or more suggestions that can be implemented and followed up at the research site.	5

Summary Statistic

Figures 2(a) and 2(b) describe the summary statistics of measurements made based on the person and item aspects. Based on the summary statistics described in Figure 2, it can be seen that the consistency of the respondents in answering has a good quality [43]–[45]. This is supported by the personal reliability value of 0.75 (Figure 2(a)). At the same time, the consistency of the items used to measure students' research skills also showed very good quality [46], [47]. This fact is illustrated by the item reliability value of 0.96. At the same time, the Cronbach alpha value is 0.77. This shows that the interaction between the person and the item used is included in the good category [43]–[45].

Based on the separation value, the ability to research the research group can be grouped into three strata, while the difficulty level of the items can be grouped up to six strata. Strata can be determined using Strata = ([4 × Separation]+1)/3 [48], [49]. The strata and separation indices estimate how well the instrument can statistically distinguish the difficulty grouping of items and people's abilities [50]. Based on the logit scale, the average research skill of the research group was 0.49 logit higher than the item difficulty level used to measure research skills. This shows that, in general, the research skills of each group are quite good.

```
    SUMMARY OF 7 MEASURED Person
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT         OUTFIT    |
|          SCORE     COUNT     MEASURE   S.E.       MNSQ   ZSTD   MNSQ   ZSTD |
|------------------------------------------------------------------------------|
| MEAN      18.1       5.0        .49    1.05         .82   -.21    .85   -.12 |
|  SEM       1.0        .0        .98     .16         .24    .40    .28    .41 |
| P.SD       2.5        .0       2.39     .39         .58    .97    .69   1.00 |
| S.SD       2.7        .0       2.58     .42         .63   1.05    .75   1.08 |
| MAX.      21.0       5.0       2.90    1.99        1.67   1.24   2.23   1.69 |
| MIN.      14.0       5.0      -4.27     .85         .04  -1.10    .03  -1.09 |
|------------------------------------------------------------------------------|
| REAL RMSE    1.19 TRUE SD     2.07  SEPARATION  1.74  Person RELIABILITY  .75 |
|MODEL RMSE    1.12 TRUE SD     2.11  SEPARATION  1.89  Person RELIABILITY  .78 |
| S.E. OF Person MEAN = .98                                                    |
-------------------------------------------------------------------------------
Person RAW SCORE-TO-MEASURE CORRELATION = .98
CRONBACH ALPHA (KR-20) Person RAW SCORE "TEST" RELIABILITY = .77  SEM = 1.21
```

(a). Statistic of person

```
    SUMMARY OF 5 MEASURED Item
-------------------------------------------------------------------------------
|          TOTAL                         MODEL         INFIT         OUTFIT    |
|          SCORE     COUNT     MEASURE   S.E.       MNSQ   ZSTD   MNSQ   ZSTD |
|------------------------------------------------------------------------------|
| MEAN      25.4       7.0        .00     .81         .93   -.26    .85   -.04 |
|  SEM       2.4        .0       2.10     .04         .26    .47    .30    .41 |
| P.SD       4.9        .0       4.20     .09         .53    .93    .61    .83 |
| S.SD       5.5        .0       4.70     .10         .59   1.04    .68    .92 |
| MAX.      30.0       7.0       8.26     .97        1.89   1.35   2.01   1.33 |
| MIN.      16.0       7.0      -3.39     .74         .33  -1.41    .29  -1.19 |
|------------------------------------------------------------------------------|
| REAL RMSE     .89 TRUE SD     4.11  SEPARATION  4.62  Item   RELIABILITY  .96 |
|MODEL RMSE     .82 TRUE SD     4.12  SEPARATION  5.05  Item   RELIABILITY  .96 |
| S.E. OF Item MEAN = 2.10                                                     |
-------------------------------------------------------------------------------
```

(b). Statistic of item

Figure 2. Summary Statistic of measure

p-ISSN: 2621-3761
e-ISSN: 2621-2889

Wright map

The hierarchical relationship between the ability to research each group and the items' difficulty level is illustrated through the Wright map in Figure 3.

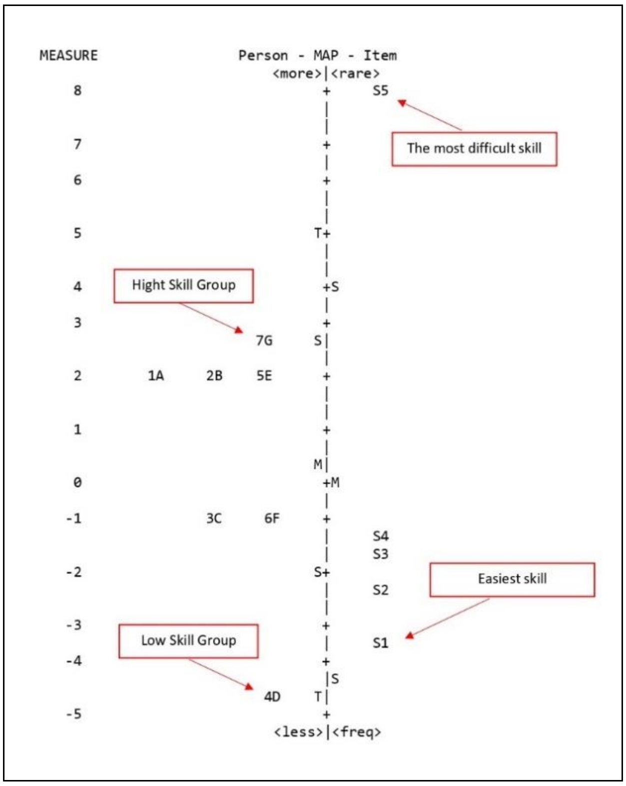

Figure 3. Wright map student research skills

Wright map is one of the features of Rasch modeling analysis using Winsteps to display the interaction between ability level and item difficulty level [51]. In general, the Wright map is divided into two sides. The left side describes the condition of a person's ability, in this case, the ability to research students. The ability to research is mapped hierarchically from top to bottom. The research group in a higher location (higher logit) has a higher level of research ability than the other groups. While the right side describes the condition of the item's difficulty level, in this case, it is an indicator of research ability [52]. Item difficulty mapping from top to bottom. Research indicators that are difficult to carry out by the research group are placed at a higher location than other items.

Figure 3 shows that the 4D group (-4.27 logit) has the lowest research ability compared to other research groups. The 4D group logit location is below all item logits on the right side. This shows that the 4D group has less than a 50% chance of mastering the five indicators of research skills used. On the same side, the 7G research group is in the highest location (2.90 logit). This shows that the 7G group is the group that has the highest level of research skills compared to other research groups. The location of the 7G group is in the top 4 indicators of research skills (S1, S2, S3, and S4). This shows that the 7G group has more than a 50% chance of mastering the four research indicators.

Based on Figure 3, on the right side (item difficulty level), it appears that item S5, “Suggestion and follow-up,” is an indicator of research skills that has the highest logit value (8.26 logit). This indicates that the S5 indicator is the most difficult skill for the entire research group. While the S1 indicator, “Identify Problems,” is the lowest indicator of research skills (-3.39 logit). This shows that the S1 indicator is mostly mastered by most of the research groups (six groups). An example of the results of the analysis of student problem identification is shown in Figure 4.

Figure 4. Identifying problems in the brick molding process

Indicator "Identifying the problems" that the research group mostly mastered because, at the apperception stage, students were given the opportunity to recall material or phenomena related to the material/research to be carried out. The second stage is the information exploration stage, providing a stimulus from various information so that students examine phenomena in the real world. Then write down a list of problems they encounter in the real world or their surroundings. At this stage, students can explore and be interested in analyzing physical phenomena close to everyday life. According to Rotgans and Schmidt [53], problem analysis of everyday phenomena can help students develop and use scientific thinking habits to solve problems. The phenomena of analyzing real-world problems analyzed per group are: 1) The concept of uniform rectilinear motion in the process of making bricks, 2) The concept of moment of force or torque in seesaw games, 3) Parabolic motion in volleyball games, 4) Simple planes in bird pulley 5), Uniform straight motion on a moving car, 6) Simple harmonic motion on a swing, and 7) Simple machine on a lorry.

At the explanation stage, students are equipped with workflow provisions in conducting research by analyzing and observing phenomena that exist in the surrounding environment and are related to the physics concepts that have been studied. Then students write them down on student activity sheets that the lecturer has given. They were also asked to record and video their observations about the physical phenomena they encountered. This is done to facilitate the analysis of physics concepts. In addition, it can attract attention and arouse enthusiasm [54]. The student presentation stage shows the results of research that has been carried out based on analysis from the real world. Each group presented it in class, and then other students gave their comments and arguments against the research results. The final stage is reflection. In this activity, the lecturer confirms to students what important concepts have been learned and understood in the research project activities.

The results of data analysis show that student skills in the indicator "giving advice and follow-up" is in the weak category or the most difficult for students to master. Some things that underlie it are students who need help understanding the problems/phenomena of physics that are studied correctly and correctly. In addition, the ability to work with a team to solve physics problems is not maximized. This can be seen in presenting results that group leaders give arguments without being based on the results of discussions with the team. These results can be overcome by providing research learning experiences to students, of course, with the scientific method, namely; 1) familiarize students with identifying problems in detail by gathering sufficient information based on observed physical phenomena/events, 2) focusing on objectives to be achieved, 3) choosing and considering appropriate methods in physics research and 4) enhancing teamwork, and correction.

Follow-up in improving research abilities for physics education students in the early semester by getting used to doing mini-research (practicum/experiment) because it maximizes the management of student practicum because, in this learning, students are equipped with various aspects of research skills and have a good understanding of research [6]. Furthermore, efforts are made by integrating research results in collaborative team-based learning because collaboration-based learning in the real world directs students to work together in small groups to achieve goals in observing physical phenomena in everyday life [55]. The opportunity to participate in scientific activities such as seminars or conferences will allow them to meet experts and learn about the latest research trends and provide direction and guidance by guiding how to prepare research objectives and questions, collect and analyze data, and compile research reports. Thus, physics education students in the early semester will be trained in conducting research, making it easier for them to complete their final assignments in the advanced semester and be useful in the future.

V. Conclusion

The CReW-A learning model is a learning model that can be used to build research skills in physical education students. Most of the indicators of research skills in most research groups have been built. Students are ready to become innovators in facing the challenges of the 21st Century through their current research skills. Even so, the indicator "Compiling suggestions and follow-up" is one of the indicators that still needs to be strengthened.

The CReW-A learning model is innovative to improve students' skills in facing the challenges of the 21st Century. Many skills can be built after using this learning model, for example, thinking skills. Therefore, we recommend that future research apply the CReW-A learning model to build various thinking skills, such as higher-order thinking skills.

VI. Acknowledgment

Thank you to LPPM Universitas Nurul Huda for providing grants for research so that this research can be carried out and completed on time.

References

[1] E. Roito, R. Solihat, and A. R. Wulan, “Pencapaian Keterampilan Meneliti Abad Ke-21 Peserta Didik SMA pada Pembelajaran Ekosistem melalui Step-By-Step Model Experiment,” *Assim. Indones. J. Biol. Educ.*, vol. 2, no. 1, pp. 14–18, Mar. 2019, doi: 10.17509/aijbe.v2i1.15112.

[2] F. Webb, C. Smith, and K. Worsfold, “Research Skills Toolkit.” Griffith Institute for Higher Education, Queensland, 2011, [Online]. Available: https://www.academia.edu/6648180/Research_Skills_Toolkit.

[3] G. Dwiyanti, A. Suryatna, and M. Nurhayati, “Optimization Experimental Procedure and Setup of a Guided Inquiry Laboratory Worksheet of Transesterification Reaction on Biodiesel Production,” *JKPK (Jurnal Kim. dan Pendidik. Kim.*, vol. 3, no. 1, pp. 38–45, May 2018, doi: 10.20961/jkpk.v3i1.11878.

[4] T. Firdaus and A. R. Sinensis, “Keterampilan Dasar Kinerja Ilmiah pada Mahasiswa Calon Guru Fisika,” *J. Pendidik. Fis.*, vol. 5, no. 2, pp. 102–110, 2017, doi: 10.24127/jpf.v5i2.985.

[5] A. Azizah and Parmin, “Inquiry Training Untuk Mengembangkan Keterampilan Meneliti Mahasiswa,” *Unnes Sci. Educ. J.*, vol. 1, no. 1, pp. 1–11, 2012, doi: 10.15294/USEJ.V1I1.848.

[6] D. Maknun, R. Y. Gloria, and J. A. Muzakki, “Keterampilan Meneliti yang Dimiliki Mahasiswa Prodi Pendidikan Biologi Se-Wilayah III Cirebon,” *J. Inov. Pendidik. IPA*, vol. 6, no. 1, May 2020, doi: 10.21831/jipi.v6i1.28251.

[7] I. Aripin *et al.*, “Pelatihan Keterampilan Meneliti Untuk Calon Guru Biologi,” *BERNAS J. Pengabdi. Kpd. Masy.*, vol. 2, no. 3, pp. 719–727, Aug. 2021, doi: 10.31949/jb.v2i3.1316.

[8] L. A. Dwiwansyah Musa and H. Hardianto, “Implementasi Pembelajaran Berbasis Riset Untuk Meningkatkan Keterampilan Meneliti Mahasiswa,” *Tadrib*, vol. 6, no. 1, pp. 1–12, Aug. 2020, doi: 10.19109/tadrib.v6i1.3786.

[9] N. J. Alsaleh, “Flipped Classrooms to Enhance Postgraduate Students’ Research Skills in Preparing a Research Proposal,” *Innov. Educ. Teach. Int.*, vol. 57, no. 4, pp. 392–402, Jul. 2020, doi: 10.1080/14703297.2019.1647269.

[10] S. Bandaranaike, “From Research Skill Development to

Work Skill Development," *J. Univ. Teach. Learn. Pract.*, vol. 15, no. 4, pp. 108–126, Oct. 2018, doi: 10.53761/1.15.4.7.

[11] D. Maknun, R. Y. Gloria, and J. A. Muzakki, "Model Kerja Lab Berbasis Proyek untuk Meningkatkan Keterampilan Meneliti dan Kesadaran Eko-Spiritual Mahasiswa S1 Program Studi Pendidikan Biologi di Wilayah III Cirebon," IAIN Syekh Nurjati Cirebon, 2019. doi: 10.21831/jipi.v6i1.28251.

[12] M. Kusnadi, N. Y. Rustaman, S. Redjeki, and I. N. P. Aryantha, "Analisis Kemunculan Keterampilan Spesifik Lab Mikrobiologi Melalui Pembelajaran Mikrobiologi Berbasis Proyek Inkuiri 'Mini-Riset' Mahasiswa Biologi," *J. Pengajaran Mat. dan Ilmu Pengetah. Alam*, vol. 17, no. 1, pp. 53–59, Jan. 2012, doi: 10.18269/jpmipa.v17i1.236.

[13] A. C. K. Leung, B. Hashemi Pour, D. Reynolds, and S. Jerzak, "New Assessment Process in an Introductory Undergraduate Physics Laboratory: An Exploration on Collaborative Learning," *Assess. Eval. High. Educ.*, vol. 42, no. 2, pp. 169–181, Feb. 2017, doi: 10.1080/02602938.2015.1089977.

[14] M. Milner-Bolotin, "Promoting Reflective Physics Teaching Through the Use of Collaborative Learning Annotation System," *Phys. Teach.*, vol. 56, no. 5, pp. 313–316, May 2018, doi: 10.1119/1.5033879.

[15] S. Tejeda and A. Dominguez, "Influence of Interactions in the Collaborative Solving of a Velocity Problem," *Int. Electron. J. Math. Educ.*, vol. 14, no. 1, pp. 91–108, Dec. 2018, doi: 10.12973/iejme/3979.

[16] J. Lämsä, R. Hämäläinen, P. Koskinen, and J. Viiri, "Visualising the Temporal Aspects of Collaborative Inquiry-Based Learning Processes in Technology-Enhanced Physics Learning," *Int. J. Sci. Educ.*, vol. 40, no. 14, pp. 1697–1717, Sep. 2018, doi: 10.1080/09500693.2018.1506594.

[17] G. Feldman, G. Schiltz, and A. Vaterlaus, "Collaborative Group Learning in a Swiss introductory physics class," *J. Phys. Conf. Ser.*, vol. 1286, no. 1, p. 012020, Aug. 2019, doi: 10.1088/1742-6596/1286/1/012020

[18] S. T. Miller and C. R. James, "What Is the Impact of Collaborative Exams on Learning and Attitudes in Introductory Astronomy Classes?," *J. Astron. Earth Sci. Educ.*, vol. 6, no. 1, pp. 17–30, 2019, [Online]. Available: https://clutejournals.com/index.php/JAESE/article/view/10289 .

[19] A. R. Sinensis, H. Firman, I. Hamidah, and M. Muslim, "Reconstruction of collaborative problem solving based learning in thermodynamics with the aid of interactive simulation and derivative games," *J. Phys. Conf. Ser.*, vol. 1157, no. 3, p. 032042, Feb. 2019, doi: 10.1088/1742-6596/1157/3/032042.

[20] D. H. Marisda, "The Effect of Task-Based Collaborative Learning on Students' Mathematical Physics Learning Outcomes at Universitas Muhammadiyah Makassar," *J. Pendidik. Fis.*, vol. 7, no. 2, pp. 140–150, May 2019, doi: 10.26618/jpf.v7i2.2038.

[21] B. M. McCollum, "Online Collaborative Learning in STEM," in *Active Learning in College Science*, Cham: Springer International Publishing, 2020, pp. 621–637.

[22] T. Firdaus, I. Hamidah, W. Setiawan, and I. Kaniawati, "Development of Collaborative Real-World Analysis Models for Physics Teacher Candidates," *J. Phys. Conf. Ser.*, vol. 1521, no. 2, p. 022043, Apr. 2020, doi: 10.1088/1742-6596/1521/2/022043.

[23] Y. Yusal, A. Suhandi, W. Setiawan, and I. Kaniawati, "The Effectiveness of Collaborative Problem-solving Using Decision-making Problems to Improve the Pre-service Physics Teachers' Critical Thinking Skills," *J. Pendidik. Fis.*, vol. 9, no. 2, pp. 107–116, 2021, doi: 10.26618/jpf.v9i2.5059.

[24] A. Çini, J. Malmberg, and S. Järvelä, "How Individual Metacognitive Awareness Relates to Situation-Specific Metacognitive Interpretations of Collaborative Learning Tasks," *Educ. Stud.*, vol. 49, no. 1, pp. 54–75, Jan. 2023, doi: 10.1080/03055698.2020.1834359.

[25] A. C. Graesser, S. M. Fiore, S. Greiff, J. Andrews-Todd, P. W. Foltz, and F. W. Hesse, "Advancing the science of collaborative problem solving," *Psychol. Sci. Public Interes.*, vol. 19, no. 2, pp. 59–92, Nov. 2018, doi: 10.1177/1529100618808244.

[26] E. B. Coleman, "Using Explanatory Knowledge During Collaborative Problem Solving in Science," *J. Learn. Sci.*, vol. 7, no. 3–4, pp. 387–427, Jul. 1998, doi: 10.1080/10508406.1998.9672059.

[27] T. S. M. Meerah and N. M. Arsad, "Developing Research Skills at Secondary School," *Procedia - Soc. Behav. Sci.*, vol. 9, pp. 512–516, 2010, doi: 10.1016/j.sbspro.2010.12.189.

[28] S. Kapon, "Doing Research in School: Physics Inquiry in the Zone of Proximal Development," *J. Res. Sci. Teach.*, vol. 53, no. 8, pp. 1172–1197, Oct. 2016, doi: 10.1002/tea.21325.

[29] Zainuriyah Abdul Khatab, "Reconceptualisation of The Construct 'Ability to Conduct A Research'and Developing A Model of An Alternative Assessment Instrument for Geography," in *Research-Driven Education Reform: Innovation for Quality Improvement*, 2019, pp. 65–85, [Online]. Available: http://backoffice.onec.go.th/uploads/Book/1027-file.PDF#page=81.

[30] Tim Pengembang SPMI, *Standar Nasional Pendidikan Tinggi*. Jakarta: Kemenristekdikti, 2014.

[31] B. Barron, "Achieving Coordination in Collaborative Problem-Solving Groups," *J. Learn. Sci.*, vol. 9, no. 4, pp. 403–436, Oct. 2000, doi: 10.1207/S15327809JLS0904_2.

[32] S. O. Bada, "Constructivism Learning Theory: A Paradigm for Teaching and Learning," *IOSR J. Res. Method Educ. Ver. 1*, vol. 5, no. 6, pp. 66–70, 2015, [Online]. Available: https://www.iosrjournals.org/iosr-jrme/papers/Vol-5 Issue-6/Version-1/I05616670.pdf.

[33] N. Rummel, A. Deiglmayr, H. Spada, G. Kahrimanis, and N. Avouris, "Analyzing Collaborative Interactions Across Domains and Settings: An Adaptable Rating Scheme," in *Analyzing Interactions in CSCL*, S. Puntambekar, G. Erkens, and C. Hmelo-Silver, Eds. Boston, MA: Springer US, 2011, pp. 367–390.

[34] T.-J. Lin, H. B.-L. Duh, N. Li, H.-Y. Wang, and C.-C. Tsai, "An Investigation of Learners' Collaborative Knowledge Construction Performances and Behavior Patterns in an Augmented Reality Simulation System," *Comput. Educ.*, vol. 68, pp. 314–321, Oct. 2013, doi: 10.1016/j.compedu.2013.05.011.

[35] K. Brundiers, A. Wiek, and C. L. Redman, "Real-world Learning Opportunities in Sustainability: From Classroom into the Real World," *Int. J. Sustain. High. Educ.*, vol. 11, no. 4, pp. 308–324, Sep. 2010, doi: 10.1108/14676371011077540.

[36] T. Firdaus, "Model Collaborative Real-World Analysis Berbantuan Video And Interfaces Analysis untuk Membekalkan Kreativitas, Kemampuan Menganalisis, dan Kemampuan Memecahkan Masalah," Universitas Pendidikan Indonesia, 2021.

[37] A. Burggraff, M. Feehan, and A. Shim, "Does Ankle Inversion or Eversion ROM Correlate With Maximal Power Output In Collegiate Women Soccer Players?," *J. Sci. Med. Sport*, vol. 24, pp. S58–S59, Nov. 2021, doi: 10.1016/j.jsams.2021.09.148.
[38] F. Bayrak, "Investigation of the Web-based Self-Assessment System Based on Assessment Analytics in Terms of Perceived Self-intervention," *Technol. Knowl. Learn.*, vol. 27, no. 3, pp. 639–662, Sep. 2022, doi: 10.1007/s10758-021-09511-8.
[39] M. Ramdhan, M. I. Sukarelawan, M. A. Thohir, and F. Arifiyanti, "Junior high school student perception of online learning in pandemic Covid-19: Gender, social media ownership, and internet access duration perspective," *Int. J. Educ. Learn.*, vol. 4, no. 1, pp. 28–40, Apr. 2022, doi: 10.31763/ijele.v4i1.517.
[40] M. H. Sandham, O. N. Medvedev, E. Hedgecock, I. J. Higginson, and R. J. Siegert, "A Rasch Analysis of the Integrated Palliative Care Outcome Scale," *J. Pain Symptom Manage.*, vol. 57, no. 2, pp. 290–296, 2019, doi: 10.1016/j.jpainsymman.2018.11.019.
[41] N. D. Eland, A. Kvåle, R. W. J. G. Ostelo, and L. I. Strand, "Rasch analysis resulted in an improved Norwegian version of the Pain Attitudes and Beliefs Scale (PABS)," *Scand. J. Pain*, vol. 13, pp. 98–108, 2016, doi: 10.1016/j.sjpain.2016.06.009.
[42] J. M. Linacre, "Winsteps® (Version 4.6.1) [Computer Software]." 2021, [Online]. Available: http://www.winsteps.com.
[43] B. Sumintono and W. Widhiarso, *Aplikasi model rasch untuk penelitian ilmu-ilmu sosial [Rasch model application for social sciences research]*. Cimahi: Trim Komunikata Publishing House, 2014.
[44] B. Sumintono and W. Widhiarso, *Aplikasi Pemodelan Rasch pada Asesmen Pendidikan*. Cimahi: Trim Komunikata, 2015.
[45] W. Rahayu, M. D. K. Putra, D. Iriyadi, Y. Rahmawati, and R. B. Koul, "A Rasch and factor analysis of an Indonesian version of the Student Perception of Opportunity Competence Development (SPOCD) questionnaire," *Cogent Educ.*, vol. 7, no. 1, p. 1721633, Jan. 2020, doi: 10.1080/2331186X.2020.1721633.
[46] A. Arslanoğlu and O. Durgut, "Linguistic Adaptation, Reliability, and Validation of the Turkish Version of the Reflux Symptom Index," *J. Voice*, vol. 36, no. 1, pp. 146.e1-146.e4, 2022, doi: 10.1016/j.jvoice.2020.04.022.
[47] E. Monaco *et al.*, "Translation, cross-cultural adaptation, and validation of the Italian version of the anterior cruciate ligament–return to sport after injury (ACL-RSI) scale and its integration into the K-STARTS test," *J. Orthop. Traumatol.*, vol. 23, no. 1, pp. 1–8, 2022, doi: 10.1186/s10195-021-00622-7.
[48] P. Govindasamy, A. Olmos, K. Green, and M. del Carmen Salazar, "Application of Many Faceted Rasch Measurement with FACETS," *Asian J. Assess. Teach. Learn.*, vol. 8, no. February 2019, pp. 23–35, 2018, doi: 10.37134/ajatel.vol8.3.
[49] B. A. Seamon, S. A. Kautz, and C. A. Velozo, "Rasch Analysis of the Activities-Specific Balance Confidence Scale in Individuals Post-Stroke," *Arch. Rehabil. Res. Clin. Transl.*, vol. 1, no. 3–4, p. 100028, 2019, doi: 10.1016/j.arrct.2019.100028.
[50] J. M. Linacre, *A User's Guide to WINSTEPS® MINISTEP Rash-model computer programs. Program Manual 4.8.0*. 2021.
[51] D. C. Briggs, "Interpreting and visualizing the unit of measurement in the Rasch Model," *Measurement*, vol. 146, pp. 961–971, Nov. 2019, doi: 10.1016/j.measurement.2019.07.035.
[52] M. I. Sukarelawan and E. Gustina, "Penelitian Alternatif di Masa Pandemi Bagi Guru Fisika: Implementasi Model Rasch dalam Penelitian Survei," in *Dinamika Pendidikan dan Pembelajaran Masa Pandemi*, D. Sulisworo, Ed. Yogyakarta: Markumi Press, 2021, pp. 189–195.
[53] J. I. Rotgans and H. G. Schmidt, "Cognitive Engagement in the Problem-based Learning Classroom," *Adv. Heal. Sci. Educ.*, vol. 16, no. 4, pp. 465–479, Oct. 2011, doi: 10.1007/s10459-011-9272-9.
[54] H. Husamah, D. Fatmawati, and D. Setyawan, "Model Pembelajaran OIDDE pada Matakuliah Pengetahuan Lingkungan untuk Meningkatkan Keterampilan Berpikir Kritis Mahasiswa Calon Guru Biologi," *J. Bioedukatika*, vol. 5, no. 2, p. 73, Jan. 2018, doi: 10.26555/bioedukatika.v5i2.7321.
[55] C. A. Dewi, M. Erna, M. Martini, I. Haris, and I. N. Kundera, "The Effect of Contextual Collaborative Learning Based Ethnoscience to Increase Student s Scientific Literacy Ability," *Turkish J. Sci. Educ.*, vol. 19, no. 2, pp. 496–510, Sep. 2021, doi: 10.36681/tused.2021.88.

Declarations

Author contribution : Arini Rosa Sinensis is responsible for all research projects and also leads the writing of manuscripts and collaborations with other authors. Thoha Firdaus participated in data collection, transcription, and analysis. Butch O Saulon played a role in providing advice in optimizing the substance of the writing.

Funding statement : LPPM Universitas Nurul Huda funded this research at 2022. Contract number: 071/STKIP-NH/LPPM/X/2021.

Conflict of interest : All of author declare that they have no conflict of interest.

Additional information : No additional information is available for this paper.