SPIN 6 (1) (2024) 42-53

SPIN

JURNAL KIMIA & PENDIDIKAN KIMIA

https://journal.uinmataram.ac.id/index.php/spin

DEVELOPMENT OF INSTRUMENTS FOR ASSESSING STUDENTS' SCIENCE PROCESS SKILLS ON ACID-BASE MATERIAL THROUGH INQUIRY-INTERNET OF THING (IIOT)

Muhamad Ali Nurdin[*1], Dede Miftahul Anwar[1], Ade Yeti Nuryantini[1], Ida Farida[1]

[1] Tadris IPA, UIN Sunan Gunung Djati, Bandung, 40292.

DOI: 10.20414/spin.v6i1.9403

History Article
Accepted:
Dec 28, 2023
reviewed:
May 13, 2024
Published:
July 13, 2024

Kata Kunci:
miskonsepsi,
representasi kimia,
sel elektrokimia,
three-tier test

Keywords:
chemical representations, electrochemical cells, misconceptions, three-tier test

ABSTRAK

Keterampilan proses sains merupakan salah satu keterampilan yang perlu dikuasai oleh siswa, karena sebagai dasar siswa memiliki kemampuan analisis yang baik. Saat ini instrumen evaluasi keterampilan proses sains hanya berupa lembar observasi yang kadangkala memberikan celah untuk guru menilai siswa secara subjektif dan belum banyak dikembangkan di materi asam basa. Oleh karena itu, penelitian ini bertujuan untuk mengembangkan instrumen tes untuk keterampilan proses sains siswa SMA pada materi Larutan Asam Basa melalui Inquiry-Internet of Thing (IIoT). Indikator yang digunakan pada instrumen ini terdiri dari sembilan indikator yang merupakan gabungan dari Keterampilan proses sains dasar dan terpadu, sedangkan metode yang digunakan pada penelitian ini adalah metode Research and Development (R&D). Tahapan pengembangan instrumen tes ini adalah membuat indikator soal, membuat soal, judgement oleh ahli materi dan ahli evaluasi, revisi soal, uji coba, revisi soal. Soal yang dikembangkan sebanyak 18 soal berupa pilihan ganda. Hasil penelitian ini menunjukkan bahwa instrumen tes yang dikembangkan memiliki Korelasi XY sebesar 0,48, Reliabilitas Tes sebesar 0,65 tingkat kesukaran dan kualitas pengecoh yang belum seimbang.Terdapat 5 soal yang sudah layak digunakan, 12 soal yang perlu direvisi, dan satu soal yang perlu diganti.

ABSTRACT

Science process skills are one of the skills that students need to master because they are the basis for students' good analytical skills. Currently, the evaluation instrument for science process skills is only in an observation sheet, sometimes providing a gap for teachers when assessing students subjectively. It has not been widely developed in acid-base materials. Therefore, this study aims to develop a test instrument for high school students' science process skills on acid-base solution material through Inquiry-Internet of Thing (IIoT). The indicators used in this instrument consist of nine indicators, which are a combination of basic and integrated science process skills. In contrast, the research and development (R & D) method is used in this research. The stages of developing this test instrument are making question indicators, making questions, judgment by material and evaluation experts, revising and testing, and revising questions. The questions developed were 18 questions in the form of multiple choices. The results of this study indicate that the test instrument developed has an XY Correlation of 0.48, Test Reliability of 0.65 difficulty level, and unbalanced quality of exacerbators. 5 questions are suitable for use, 12 questions that need to be revised, and one question that needs to be replaced.

How to Cite

Nurdin, M. A., Anwar, D. M., Nuryantini, A. Y., & Farida, I. W., (2024). Development of Instruments for Assessing Students' Science Process Skills on Acid-Base Material Through Inquiry-Internet of Thing (IIoT). *SPIN-Jurnal Kimia & Pendidikan Kimia*. 6(1). 42-53.

[*]Correspondence Author:
Email: ghazi.ali.nurdin@gmail.com

p-ISSN: 2580-2623
e-ISSN: 2745-6854

INTRODUCTION

A test instrument is needed to measure whether the learning that has been carried out is successful or not. One of the learning outcomes that is very important in measuring success is science process skills (Ilmi et al., 2016). Science process skills are a learning approach that focuses on developing students' skills in processing knowledge, discovering and developing the necessary facts, concepts, and values themselves (Maison et al., 2020). Science process skills are used as a reference in developing this instrument because science process skills are the skills to think, reason, and act logically to research and build scientific concepts that are useful for solving scientific problems (Miharti et al., 2021; Farida 2019). Therefore, it is very relevant to develop science process skills using an inquiry approach to the Internet of Things. Inquiry-IoT (IIoT) is learning with an inquiry model that is integrated with the Internet of Things in a network device that is able to identify an object based on certain additional sensors into data and can be accessed and controlled wirelessly (Davies, 2020). Current technology has the potential to reform assessment (Nuryantini, 2020). With the Internet of Things, students can develop their technological insight, especially those related to networks involving devices, sensors, cloud, and actuators, and all of these need to be connected to each other to be able to decipher data and consequently carry out an action (Mazhar et al., 2023). So this will help improve students' science process skills.

In reality, in the field, evaluations to measure the learning process are mostly limited to the knowledge aspect only. This is because the learning process still uses conventional learning methods (Kemdikbud, 2013). Science learning generally seeks to improve students' scientific literacy and science process skills. However, research shows that much learning is still designed to emphasize mastery of content (Kopacz & Handlos, 2021). Of course, this will impact the evaluation process carried out, which should evaluate the science process skills possessed by students; in reality, it only focuses on the content knowledge aspect (Duda & Susilo, 2018). Every school must be able to equip students to have the ability to integrate the knowledge gained with real life in responding to global challenges (Kriswantoro et al., 2020). A significant obstacle felt by teachers in planning and evaluating learning lies in the efficiency of time and the breadth of material that must be delivered, so it is not effective for developing science process skills (Kramer et al., 2018).

The use of the inquiry method is one of the appropriate learning methods for developing science process skills (Şahintepe et al., 2020). Learning using the inquiry method is considered the most widely used learning to encourage creativity in science education, especially science process skills (Johnson A, 2000). The phases of the inquiry-based learning model guide the activities of teachers and students in learning activities, especially when carrying out experiments or investigations to improve students' science process skills (Bekir Güler, 2019). The first phase of learning orientation begins by providing trigger questions to explore information on students' mastery of the material while connecting it with aspects of daily life to increase students' motivation and level of curiosity. Next, in the second phase, or problem definition phase, students are given examples of problems related to acids and bases, and students are asked to gather information, process information, and collect data to determine what problem will be studied. In the third phase or hypothesis proposal phase, students begin to formulate the problem, combine supporting concepts, and propose a hypothesis about the problem to be researched. In the fourth phase, or hypothesis testing phase, the teacher guides students to carry out observations, investigations, mutual discussions, and other aspects of science process skills until a solution is found from the problem formulation being studied. The fifth phase, or evaluation and follow-up phase, is the final phase, where students create research reports, communicate research results, and prepare follow-up investigations from the research (Panjaitan & Siagian, 2020).

Based on these problems, it is very necessary to have an instrument development process to measure students' science process skills that are needed by teachers. The type of instrument developed by researchers is an objective test in the form of multiple choice (PG) to measure students' science process skills (Suryani et al., 2015). Science process skills are divided into two levels: basic level process skills (basic science process skills) and integrated process skills (the integrated science process skills). Basic level process skills include Observation, classification, communication, measurement, prediction, and inferring. Integrated process skills include determining variables, compiling data tables, compiling graphs, providing variable relationships, processing data, analyzing investigations, compiling hypotheses, determining variables operationally, planning investigations, and experimenting (Farida, 2019). In this research, nine variables will be used, which are a combination of basic and integrated process skills. This combination was carried out to see students' science process skills as a whole (Lepiyanto, 2017).

There are several previous studies that correlate with this research, including research conducted by Sholihah et al. (2019), who developed a two-tier multiple-choice instrument to measure students' science process abilities. The results of the analysis show that the instrument provides good results. However, it still needs to be improved and developed further to provide better results so that it can be used as an appropriate instrument to measure science process skills (Sholihah et al., 2019). In addition, Şahintepe et al. (2020) also conducted research to analyze the effect of science learning using an inquiry-based approach on the level of science process skills of class VII students, and the results showed that this approach was effective in improving students' science process skills (Şahintepe et al., 2020). In another study, Sukarmin et al. (2018) also conducted research in developing instruments to measure students' science process skills, especially the ability to formulate hypotheses, design experiments, analyze data, apply concepts, communicate, and make conclusions (Sukarmin et al., 2018). In biology lessons, Demirçalı et al. (2022) conducted an analysis of the effect of guided inquiry on students' Science Process Skills (SPS) and Interpersonal Intelligence (KI). The analysis results show that students who take guided inquiry classes have better competencies, both in SPS and KI. Therefore, guided inquiry significantly contributes significantly to increasing students' SPS and IQ (Demirçalı & Selvi, 2022).

Based on the research above, they all strive to develop learning and instruments to measure students' science process skills. The difference between this research and previous research lies in a) Combining mastery of concepts with skills as an instrument model used to measure science process skills, b) inquiry learning integrated with IoT on acid-base material, and c) the research objectives to be achieved are to produce a valid instrument in measuring students' process skills in acid-base IIoT learning d) This research uses nine variables which are a combination of basic process skills and integrated process skills. It is hoped that through this research a quality instrument can be obtained to measure the science process skills of grade XI students in acid-base solution material.

METHODS

The methodology in this research is initial research for further research, so this research uses 3 development steps by Borg and Gall which are simplified without any implementation process, namely (1) Preliminary Study, (2) instrument design, (3) testing and revision (Gunartha, 2020). Figure 1 shows the flowchart at each stage.

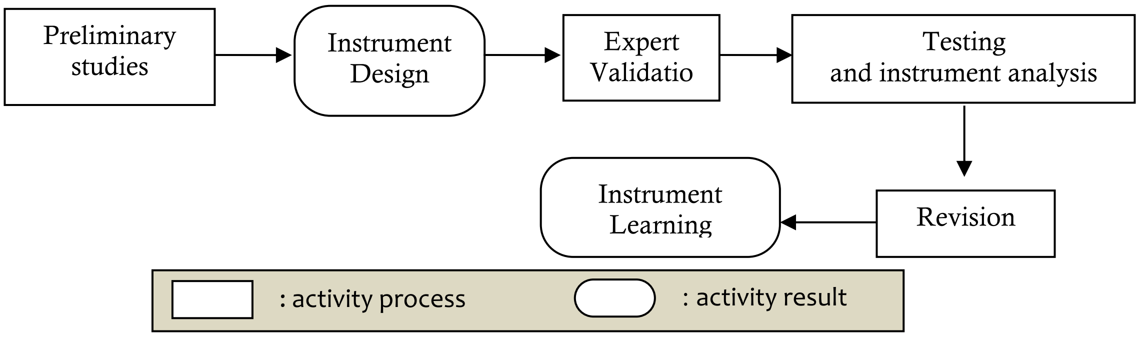

Figure 1. Flowchart of research stages

In the initial stage, a preliminary study was carried out in the form of a theoretical study of evaluation instrument models to measure science process skills as well as a study of the results of research that had been carried out. At this stage, nine indicators of scientific process skill are determined, which will be developed into instruments, namely 1) grouping/classifying, 2) interpreting/interpreting, 3) predicting/predicting, 4) measuring, 5) hypothesizing, 6) planning experiments/research, 7) using tools/materials, 8) controlling variables, 9) communicating.

Next, a draft instrument was designed based on the results of the preliminary study. The draft consists of instruments to measure students' science process skills. All of these instruments are in the form of multiple-choice (MC) questions. Then, the draft instrument was validated by experts, namely lecturers and practitioners (teachers), to check the validity of the content and perfect the draft instrument. Efforts to create tests with high content validity can be made by (1) compiling a test grid before writing or selecting the statement items to be tested and (2) creating statement items on the test that are guided by the curriculum (Farida, 2017).

After being validated by experts, the instrument was tested on students, and a quantitative validation process was carried out. This process was carried out to see the reliability, validity, level of difficulty, distinguishing power, and quality of distractors using the Anatest V4 program with interpretations and criteria as in Table 1 below.

Table 1. Interpretation of correlation index, difficulty level, and discriminating power

Correlation index		Difficulty level		discriminating power	
Score	Criteria	Score	Criteria	Score	Criteria
0,00 – 0,20	Very low	0,00 – 0,15	Very Difficult	0,00 – 0,19	Very Poor
0,21 – 0,40	Low	0,16 – 0,30	Difficult	0,20 – 0,29	Poor
0,41 – 0,60	Enough	0,31 – 0,70	Medium	0,30 – 0,39	Enough
0,61 – 0,80	High	0,71 – 0,85	Easy	0,40 – 0,70	Good
0, 81 – 1,00	Very High	0, 86 – 1,00	Very Easy	0, 71 – 1,00	Very Good

The validity of an instrument shows the extent to which it can measure (provide information) that is appropriate and can be used to achieve certain goals. A test like this is said to be valid. The correlation coefficient price range is between 0 and 1 with categories as in Table 1 above (Arikunto, 2013).

Meanwhile, reliability is the level or degree of constancy of a test instrument. This shows that whenever this assessment tool is used, it will provide consistent results. Reliability analysis of an instrument is carried out for all question items, not each question item (Farida, 2017).

To see the level of difficulty, if a question has a balanced level of difficulty (proportional), it means the question is good because it is not too difficult but not too easy. The range of difficulty index values with categories are as in Table 1 above (Karnoto, 1996).

The discriminating power of a question (D) or discrimination index is the ability of a question to differentiate between students with high ability and students with low ability. The range of discriminating power (D) values is between -1 to 1 with categories as in Table 3 above. If D has a value of 0.00 – 0.19, then the question can be used after improvements have been made. If D is negative, the question item cannot be used because it shows the student's reverse quality (Farida, 2019).

Distractor (distractor) analysis was carried out to determine the functionality of each answer choice in a multiple-choice question. A distractor that is not chosen at all by students indicates that the distractor is bad. A director is said to be functional if at least 5% of students who take the test are chosen (Farida, 2019).

After obtaining the data from the Anates results, revisions or improvements to the instrument were then carried out in accordance with the advice obtained from experts and practitioners. The improved instrument is ready to be used to measure students' process skills.

The trial process of this instrument was carried out on 33 students of class XI Science at SMA YADIKA Sumedang. Data from the trial results were then analyzed using Confirmatory Factor Analysis (CFA) via the IBM SPSS application to test the extent to which the data obtained was in accordance with the theoretical model that had been previously formulated. At the evaluation stage, the average score from the quantitative data obtained is calculated and then interpreted qualitatively on a scale of 5 using instrument assessment criteria modified from the rules developed by Sudijono (Gunartha et al., 2020), as shown in Table 2. The results of the qualitative analysis are used as a basis for determining whether the instrument being developed is feasible or not.

Table 2. Instrument assessment criteria

Average Score	Criteria	Conclusion
>4,2	Very Good	Able to be a reference
>3,4 – 4,2	Good	Able to be used without revision
>2,6 – 3,4	Quite Good	Able to be used with minor revisions
>1,8 – 2,6	Poor	Able to be used with several revisions
≤1,8	Not good	Not able to be used

RESULT AND DISCUSSION

Science Process Skills and Acid-Base Material

After a preliminary study, an instrument design was created based on the science process skills (SPS) indicators. The following is the distribution of questions according to the SPS indicators tested.

Table 3. Distribution of questions according to SPS indicators

NO	SPS INDICATORS	ITEM NO
1	Grouping/Classification	1, 2
2	Interpreting/Interpreting	3, 4
3	Forecast/prediction	5, 6
4	Measure	7, 8
5	Hypothesize	9, 10
6	Planning experiments/research	11, 12
7	Using tools/materials	13, 14
8	Controlling Variables	15, 16
9	Communicate	17, 18

An inquiry learning model with acid-base material was chosen to maximize the results of analyzing students' science process skills (Lusidawaty, 2020).

Science process skills in the process involve a series of skills, including intellectual, manual, and social skills, that are used to build an understanding of a concept or idea and solve scientific problems. Therefore, it is necessary to select skill indicators that are included in science process skills that are adapted to the material and student grade level (Sibic & Sesen, 2022). Regarding the research subject of class

The acid-base material chosen to develop scientific process skills includes 1) Acid-base theory, 2) Identification of acid-base solutions, 3) Strength of acid-base, and 4) degree of acidity (pH) (Brady, 1999). This material was chosen because it can be delivered using an inquiry learning model using the Internet of Things media through a practicum method. This process makes it easier to involve all the indicators that will be analyzed (Abichandani et al., 2022). Inquiry-based learning has proven to be a promising method for science education. However, despite its advantages, this method is rarely used in teaching chemistry. One reason is the lack of tried and tested inquiry-based teaching materials with detailed guides that teachers can easily use in their classrooms. Guided inquiry learning is suitable for students who are new to this method if given the right scaffolding. The data shows the phases of the inquiry cycle that require more guidance are needed. Formulating hypotheses, recording observations, and evaluating hypotheses based on existing evidence were found to be the most important steps in the learning process. The results of the student questionnaire showed that students enjoyed the inquiry sessions, and most of them felt their work was successful (Orosz, 2023).

Expert Validation

The validation process was carried out on 3 experts, 2 school teachers, and 1 lecturer, with the following results.

Table 4. Expert validation results

No	Aspect	Average	Criteria
1	Clarity of instrument instructions	4,97	very suitable
2	Completeness of instrument indicators	4,98	very suitable
3	Completeness of instrument indicators	4,97	very suitable
4	Language Effectiveness	4,81	very suitable
Mean		4,93	Very suitable

There are three things that can be done to produce a quality assessment tool, namely through 1) validity analysis, 2) reliability analysis, and 3) item analysis (differentiating power, level of difficulty, and quality of distraction) (Farida, 2019).

Based on Table 4 above regarding the clarity of the instrument instructions, the completeness of the instrument indicators, the suitability of the indicators with the instrument statements, and the effectiveness of the language, it shows that based on expert validation, this instrument is very suitable for use because it has high validity. The processes that have been carried out to ensure high validity include: 1) compiling a test grid before writing or selecting the question items to be tested, 2) creating or selecting question items on the test based on learning objectives and learning outcomes according to the curriculum (Farida, 2019). This expert validation process is very important because it serves as an initial reference before testing the instrument on students, as a continuation to determine the quality of the instrument quantitatively (Sukardiono et al., 2019).

Results of Question Item Analysis

The results of data processing obtained information regarding distinguishing power, level of difficulty, correlation, and reliability, as in Table 5 below.

Table 5. Results of item analysis with Anates

Item no	Discriminating power		Difficulty level		Correlation of item score with total score	
	Score	Category	Score	Difficulty level	Correlation	Interpretation of correlation
1	-0,33	Not Good	0,21	Difficult	-0,28	-
2	0,33	Medium	0,67	Medium	0,27	Low

Item no	Discriminating power		Difficulty level		Correlation of item score with total score	
	Score	Category	Score	Difficulty level	Correlation	Interpretation of correlation
3	0,11	Poor	0,55	Medium	0,05	Very Low
4	0,11	Poor	0,12	Very Difficult	0,26	Low
5	0,67	Good	0,72	Easy	0,53	Medium
6	0,22	Medium	0,12	Very Difficult	0,16	Very Low
7	0,11	Poor	0,18	Difficult	0,18	Very Low
8	0,11	Poor	0,03	Very Difficult	0,46	Medium
9	0,00	Poor	0,15	Difficult	0,15	Very Low
10	0,00	Poor	0,42	Medium	0,07	Very Low
11	0,44	Good	0,18	Difficult	0,55	Medium
12	0,56	Good	0,24	Difficult	0,61	High
13	0,00	Poor	0,09	Very Difficult	0,02	Very Low
14	0,33	Medium	0,27	Difficult	0,27	Low
15	0,67	Good	0,3	Difficult	0,57	Medium
16	0,78	Very Good	0,24	Difficult	0,61	High
17	0,22	Medium	0,18	Difficult	0,18	Very Low
18	0,22	Medium	0,21	Difficult	0,25	Low

Mean = 4.91 Standard deviation = 1.97 XY Correlation = 0.48 Test Reliability = 0.65

The results of data processing also provided information regarding the distractor quality of each question item, as shown in Table 6 below.

Table 6. Distractor Quality

Item No	Distractor Quality				
	A	B	C	D	E
1	1--	7**	10-	3-	12--
2	1-	7---	3++	0--	22**
3	7--	18**	2+	4++	2+
4	6++	6++	1--	4**	16---
5	3+	1-	24**	1-	4--
6	5+	2-	16---	4**	6++
7	2'-	2-	6**	14---	9+
8	0--	21---	1**	4-	7++
9	17---	2-	2-	7++	5**
10	5++	6+	4++	14**	4+
11	3-	6**	8++	13--	3-
12	1--	2-	3-	8**	19---
13	10+	1--	3-	3**	16---
14	1--	5++	9**	18---	0--
15	4+	10**	2-	4+	13---
16	8**	4+	13---	3-	5++
17	9+	13--	6**	2-	3-
18	3-	18---	7**	5++	0--

Description: ** : Answer Key ++ : Very Good + : Good - : Not Good -- : Bad ---: Very Bad

Based on the results of the data analysis above, many revisions must be made for each question item. This is because each question item has varying differentiating power, validity, difficulty level, and distractor quality. The following are the results of the analysis of each question item.

a. Good problem

Of the 18 questions tested, only 5 questions were categorized as good and could be used without having to be revised, namely questions number 5, 11, 12, 15, and 16. In general, these questions met the criteria as good quality questions based on their discriminating power, difficulty level, distractor quality, validity, and reliability.

For question number 5, this question aims to measure students' forecasting/prediction abilities. Students were given a statement regarding the increase in carbon dioxide (CO2) levels in the atmosphere, resulting in changes that trigger acidification or acidification in seawater. This acidification has an impact on the local ecosystem, which affects the habitat of coral reefs and the coral reef fish associated with them. Also displayed is a picture of a coral reef. Then, students are asked to predict the possible impact of increasing carbon dioxide on coral reefs and the surrounding environment. This question is in the easy category because 24 of the 33 students answered correctly. This is because the majority of students are now familiar with the beach environment because they often travel to the area. Of the 9 students who answered incorrectly, 4 people answered that the impact was that coral reefs did not develop, so they were easy to take as trinkets. This option is attractive to them because they know that on the beach, there are lots of trinkets from coral reefs.

For questions number 11 and 12, this question aims to measure students' ability to plan experiments/research. In question number 11, students are asked whether they want to know what the Ka value of 100 mL of 0.1 M CH3COOH solution is and how to design the experiment. Meanwhile, in question number 12, students were asked if they wanted to use butterfly pea flowers as a natural indicator to find out whether a solution was acidic or basic and how to plan the experiment. This question is in the difficult category because it is related to the planning process of an experiment or practicum. Of course, children who do not prepare well during their practicum will have difficulty determining the steps. However, the discriminating power of this question is good, and its validity is high. So even though the category is difficult, this question has quality because it can measure well which students have the ability to plan experiments/research and those who don't. This is shown in number 11 of the 6 people who answered correctly, 4 people from the superior group, and 2 people from the medium group. Meanwhile, in number 12 out of 8 people who answered correctly, 5 people were from the superior group, and 3 people were from the medium group.

For questions number 15 and 16, this question aims to measure students' ability to control variables. Students are given the problem of how to differentiate strong acids, weak acids, strong bases, and weak bases from a solution. Then, they decided to carry out an investigation and prepared several solutions: strong acid, strong base, weak acid, and weak base, each having the same volume and concentration. Next, the four solutions were tested for electrolytes to determine the flame of the lamp and gas bubbles, as well as an acid-base test using red and blue litmus indicators. The difference is that in question number 15, students are asked to determine the dependent variable; in question number 16, they are asked to determine the independent variable. This question is in the difficult category because it is still related to experiments. There is also the possibility that students are still confused about differentiating between dependent variables and independent variables. However, the discriminating power of this question is good, and its validity is high. So even though the category is difficult, this question is quality because it can measure well which students have the ability to control student variables and those who don't. This is shown by the majority of students who answered correctly coming from the superior group.

b. Questions that need to be revised

Of the 18 questions tested, there were 12 questions that were in the category that needed to be revised, namely questions number 2, 3, 4, 6, 7, 8, 9, 10, 13, 14, 17 and 18. In general, these questions did not meet the requirements. criteria as quality questions, both in terms of differentiating power, level of difficulty, quality of distractors, validity, and reliability.

Question number 2 aims to measure students' grouping/classification abilities. Students are given data on electrolyte test results and litmus color changes from 5 solution samples and then asked to choose the correct statement. There is no problem with the level of difficulty and distinguishing power of this question, only the quality of the distractor choices D is bad and B is very bad. Option B is very bad because the writing is different from the other options, so it needs to be adjusted. Likewise, option D is considered bad because, in the answer, there is solution A, which is clearly a weak acid, so this question needs to be revised for options B and D.

Question number 3 aims to measure the ability to interpret/interpret. Students are given some data on color changes of natural indicators in acid-base experiments. Then, from the results of the experiment above, students are asked to draw conclusions. There is no problem with the level of difficulty and distinguishing power; the quality of distractor choice A is poor. Option A is considered bad because it looks different from the writing pattern of the other options, and it is too clear that there is no possible answer, so this question needs to be revised with option A.

Question number 4 aims to measure the ability to interpret/interpret. Students are given a problem regarding the relationship between the Ka value and the pH of a solution at the same concentration. Then, the ionization constant (ka) of several weak acids with the same concentration is given in each solution. This question is considered very difficult because the language of the question is too complicated, so students have difficulty understanding the question, and it is confusing to solve it. Therefore, the wording of the question needs to be simplified further. The quality of the distractor options C and E is poor, and they need to be revised. This is because the sentence is striking and different from the other sentences, so the majority answered this option, especially option E. Revision was carried out by paraphrasing and made comparable to the other options.

Likewise, with other questions that need to be revised, in terms of validity and reliability, they are good; only a few distractions need to be revised because 1) the sentences are too ambiguous and irrelevant, 2) the sentences are not simple, 3) the sentences are too flashy and clearly wrong. So, this option is not chosen by students, or many people choose it even though it is not the answer key. A distractor that is not chosen at all by the students being tested shows that the distractor is bad (Farida, 2019).

c. Questions that should not be used

Of the 18 questions tested, there was 1 question that fell into the category that had to be replaced or should not be used, namely question number 1. This question had negative validity and reliability values. Negative discriminating power (<0) means that more of the lower group or students who do not understand the material answered correctly compared to the upper group or students who understand the material taught by the teacher. Of course, this shows that this question cannot be trusted and cannot measure the desired indicators.

Question 1 aims to measure students' grouping/classification abilities. Students are given data on the Ka values of several weak acids, as in Table 7 below.

Table 7. Ka values for some weak acids

Asam	Ka
HA	$1,8 \times 10^{-4}$
HB	$1,8 \times 10^{-5}$
HC	$6,7 \times 10^{-5}$
HD	$0,3 \times 10^{-4}$
HE	$7,2 \times 10^{-6}$

Then, students were asked to order the acids from the weakest. Of the 7 students who answered correctly, not a single student from the superior group answered correctly. If you look at their answers, everyone was fooled in sorting HB, HC, and HD. This means that even though this question cannot measure students' grouping/classification abilities, from this question we can see that students' understanding of the concept of negative numbers is still low. And, of course, this is very useful information for teachers to improve their understanding of negative numbers.

Based on the analysis of the data processing results for the 18 questions above, this research can then be continued with the implementation of the revised instrument and measuring students' science process skills in acid-base solution material.

CONCLUSION

The conclusion that can be drawn based on the results of the research carried out is that the scientific process skills test instruments in the Chemistry subject for the Acid and Base Solutions material that were developed are stated to not all be able to be used. The development of an instrument for assessing science process skills in this research is a multiple choice test instrument with nine indicators of science process skills. The questions developed were 18 questions. There are 5 questions that are suitable for use, 12 questions that need to be revised, and one question that needs to be replaced. Therefore, after the revision is carried out, researchers can then develop the science process skills test instrument again to make it even better and develop chemistry learning in the chapter. Acid-Base Solution using the IoT-inquiry method.

REFERENCES

Abichandani, P., Sivakumar, V., Lobo, D., Aboni, C., & Shekhara, P. (2022). Internet-of-Things Curriculum, Pedagogy, and Assessment for STEM Education: A Review of Literature. *IEEE Access*. doi:10.1109/ACCESS.2022.3164709

Arikunto, S. (2013). *Dasar-Dasar Evaluasi Pendidikan.* jakarta: Penerbit PT Bumi Aksara,.

Bekir Güler, M. Ş. (2019). Using Inquiry-Based Experiments to Improve Pre-Service Science Teachers' Science Process Skills. *International Journal of Progressive Education, , 15*. doi:DOI: 10.29329/ijpe.2019.212.1

Brady, J. (1999). *Kimia Universitas Asan dan Struktur* (kelima ed.). Binarupa Aksara: Binarupa Aksara.

Davies, D. B. (2020). The potential of the 'Internet of Things' to enhance inquiry in Singapore schools. *Research in Science and Technological Education*, 484–506.

Demirçalı, S., & Selvi, M. (2022). Effects of Model-Based Science Education on Students' Academic Achievement and Scientific Process Skills. *Journal of Turkish Science Education, 19*(2), 545-558. doi:DOI no: 10.36681/tused.2022.136

Duda, H. J., & Susilo, H. (2018). Science Process Skill Development: Potential Of Practicum Through Problems Based Learning And Authentic Assessment. *Anatolian Journal of Education, 3*, 51-60. doi:https://doi.org/10.29333/aje.2018.315a

Farida, I. (2019). *Evaluasi Pembelajaran.* Bandung: PT Remaja Rosdakayra.

Ga´bor Orosz, a. V. (2023). Guided inquiry-based learning in secondaryschool chemistry classes: a case study. *The Royal Society of Chemistry, 24*, 50–70. doi:DOI: 10.1039/d2rp00110a

Gunartha, I. W. (2020). Developing instrumens for measuring the level of early childhood development. *Research and Evaluation in Education*.

ilmi, N., Desnita, & handoko, E. (2016). Pengembangan Instrumen Penilaian Keterampilan Proses Sains Pada Pembelajaran Fisika Sma. *Program Studi Pendidikan Fisika UNJ.*

Johnson A, P. (2000). *Nail dan keluar : Menggunakan keterampilan berpikir kreatif dan kritis untuk meningkatkan pembelajaran.* Boston: Mass : Allyn and Bacon.

Kemdikbud. (2013). *Bahan Pelatihan.* Jakarta: Kementerian Pendidikan Nasional.

Kopacz, D. M., & Handlos, Z. J. (2021). Less is More: Course Redesign and the Development of an Atmospheric Science Process Skills Assessment. *J-SoTL, 15*. doi:https://doi.org/10.20429/ijsotl.2021.150212

Kramer, M., Olson, D., & Walker, J. D. (2018). Design and Assessment of Online Interactive Tutorials That Teach Science Process Skills. *CBE—Life Sciences Education*. doi:DOI:10.1187/cbe.17-06-0109

Kriswantoro, Kartowagiran, B., & Rohaeti, E. (2020). A Critical Thinking Assessment Model Integrated with Science Process Skills on Chemistry for Senior High School. *European Journal of Educational Research, 10*(1), 285 - 298. doi:https://doi.org/10.12973/eu-jer.10.1.285

Lepiyanto, A. (2017). Analisis keterampilan proses sains pada pembelajaran berbasis praktikum. *BIOEDUKASI (Jurnal Pendidikan Biologi), 5*(2), 156-161.

Lusidawaty, V. F. (2020). Pembelajaran IPA dengan strategi pembelajaran inkuiri untuk meningkatkan keterampilan proses sains dan motivasi belajar siswa di sekolah dasar. *urnal Basicedu, 4*(1), 168-174.

Maison, Darmaji, Aatalini, Kurniawan, D. A., Lumbantoruan, A., & Dewi, U. P. (2020). Science Process Skill in Science ProgramHigher Education. *Universal Journal of Educational Research*.

Mazhar, T., Irfan, H. M., Haq, I., Ullah, I., Ashraf, M., Shloul, T. A., . . . Elkamchouchi, D. H. (2023). Analysis of Challenges and Solutions of IoT in Smart Grids Using AI and Machine Learning Techniques: A Review. *Electronics*. doi:https://doi.org/10.3390/electronics12010242

Miharti, S. F., Harizon, & Zurweni. (2021). Development of student worksheet for blended learning based guide inquiry and science process skill in reduction and oxidation reaction. *Jurnal Pendidikan Kimia*.

Nahadi, W. S. (2014). *Pengembangan Tes Diagnostik Two-Tier dan Manfaatnya dalam Mengukur Konsepsi Kimia Siswa SMA.* Bandung: Jurusan Pendidikan Kimia.

Nurdin, M.A., Miftahul Anwar,D., Yulia., Sumiati., (2023) Modul Ajar pembelajaran asam basa. "*unpublished"*

Nurdin, M.A. (2023). Hasil analisis SPSS instrumen keterampilan proses sains siswa.

Nurdin, M.A. (2023). Hasil analisis validasi modul ajar dan Lembar Kerja Peserta Didik.

Nuryantini, A. Y. (2020). Tinjauan Kurikulum dan Model Pembelajaran di Era Digital.

Panjaitan, M. B., & Siagian, A. (2020). The Effectiveness of Inquiry Based Learning Model to Improve Science ProcessSkills and Scientific Creativity of Junior High School Students. *Journal of Education and e-Learning Research*.

Şahintepe, S., Erkol, M., & Aydoğdu, B. (2020). The Impact of Inquiry Based Learning Approach onSecondary School Students' Science Process Skills. *Open Journal for Educational Research*.

Sholihah, N. A., Sarwanto, & Aminah, N. S. (2019). Development of two-tier multiple choice instrumentto measure science process skill. *Journal of Physics: Conference Series*.

Sibic, O., & Sesen, B. A. (2022). Examining Science Process Skills Tests: A Case of Turkey. *International Journal of Assessment Tools in Education, 9*, 20–38. doi:https://doi.org/10.21449/ijate.1058055

Sukardiono, Rosana, D., & Dwandaru, W. S. (2019). Measuring Junior High School Students' Science Learning and Science Process Skills through an Integrated Science Instructional Assessment. *Journal of TURKISH SCIENCE EDUCATION, 16*(4), 467-477. doi:doi: 10.36681/tused.2020.1

Sukarmin, Ratnasari, D., & Suparmi. (2018). The Instrument Implementation of Two-tier Multiple Choice to Analyze Students' Science Process Skill Profile. *International*

Journal of Pedagogy and Teacher Education (IJPTE).

Suryani, A., Siahaan, P., & Samsudin, A. (2015). Pengembangan Instrumen Tes untuk Mengukur Keterampilan Proses Sains Siswa SMP pada Materi Gerak. *Prosiding Simposium Nasional Inovasi dan Pembelajaran Sains*.