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Development of student's initial ability test based on generic science skills

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ARTICLE INFO	ABSTRAK
	Penelitian ini bertujuan untuk mengembangkan instrumen tes kemampuan awal berbasis keterampilan generik sains pada materi kesetimbangan kimia. Penelitian ini menggunakan model pengembangan 4D yaitu Define, Design, Development dan Disseminate. Instrumen tes kemampuan awal disesuaikan dengan indikator keterampilan generik sains. Produk akhir yang dihasilkan terdiri dari tes skolastik dan tes kimia berbentuk pilihan berganda,dimana tes skolastik akan menunjang penyelesaian tes kimia. Instrumen yang dikembangkan diuji kelayakannya ditinjau dari validitas isi oleh ahli dan ditinjau dari validitas konstruksi dari hasil uji coba lapangan pada siswa di SMA kelas XI. Hasil analisis data menunjukkan bahwa instrumen tes kemampuan awal berbasis keterampilan generik sains yang dikembangkan telah memenuhi kelayakan validitas isi dengan rata rata persentase penilaian 90 persen dengan kategori sangat valid dan memenuhi kelayakan validitas konstruksi sehingga instrumen dianggap baik. Instrumen tes kemampuan awal ini efektif dan layak digunakan dalam proses pembelajaran yang dapat dijadikan sebagai alat untuk mengukur kemampuan awal serta meningkatkan keterampilan generik sains pada siswa.

ABSTRACT

This study aims to develop an initial ability test instrument based on generic science skills in chemical equilibrium material. This study uses a 4D development model, namely Define, Design, Development and Disseminate. The initial ability test instrument is adapted to indicators of generic science skills. The final product produced consists of a scholastic test and a chemistry test in the form of multiple choices, where the scholastic test will support the completion of the chemistry test. The feasibility of the developed instrument was tested in terms of content validity by experts and in terms of construction validity from the results of field trials on students in class XI SMA. The results of data analysis show that the initial ability test instrument based on generic science skills that has been developed has met the eligibility of content validity with an average percentage of 90 percent with a very valid category and meets the feasibility of construction validity so that the instrument is considered good. This initial ability test instrument is effective and appropriate for use in the learning process which can be used as a tool to measure initial abilities and improve generic science skills in students.

INTRODUCTION

Education is a conscious effort to prepare students who will play a role in the future through guidance, learning, and training activities (Sulastri et al., 2020). Education as a forum for the learning process will produce students who actively expand their potential so that they have the personality, intelligence, and skills will be needed by themselves and society (Prasetyaningrum et al., 2013). A quality learning process will make students master the learning objectives that can be seen through the production of meaningful learning. This is in accordance with Ausubel's theory which states that meaningful learning is learning that allows a person to connect the new knowledge he will acquire with the knowledge he has previously acquired that has been attached to him (Hamida et al., 2022).

Chemistry is an offshoot of science that learn matter in its structure, properties, composition, and changes. Chemistry has 2 characteristics namely as a product and chemistry as a process. Chemistry as a product consists of a combination of knowledge consisting of facts, principles, laws, and concepts of chemistry while Chemistry as a process relates to attitudes and scientific work which includes skills in discovering and developing chemical products (Herdiawan et al., 2019). PISA (the Program for International Student Assessment) is a program that measures performance in mathematics, science, and literacy which is a reference for evaluating the quality of education. Based on the results of the PISA from 2000 – 2018, Indonesia's scientific ability is still relatively low, which is always ranked in the bottom 10 (Hewi & Shaleh, 2020). One that influences this is the initial ability of students.

The initial ability is the result of learning obtained before proceeding to the next stage and become the basic foundation for students to learn any learning material that will be given by the teacher (Mulyono et al., 2018). Students' initial abilities also describe the readiness of students to participate in a lesson. By knowing the initial abilities of students, the teacher will use them as a reference for determining the starting point of a lesson, forms of classroom management, choosing learning methods and approaches and forms of assessment that are effective for students (Gomes, 2019).

The research of Silitonga et al., (2022) shows that, the initial ability has the greatest contribution to chemistry learning outcomes. This is understandable because the initial ability is the basis for understanding concepts in starting a new concept that describes students' readiness to enter new material. This is conducted with the research of Panggabean et al., (2022) reveals that students' initial abilities and students' HOTS abilities have a positive and significant relationship.

Entering the 21st century, education in Indonesia faces various challenges and opportunities that are different from the previous century. To anticipate and adapt to the various demands and dynamics of learning developments that will occur in the 21st century, Indonesian education must be prepared to improve the skills and abilities needed in the 21st century. This aspect of 21st Century skills has a very close intersection with generic science skills (Haviz et al., 2018). Learning science, especially chemistry, requires generic science skills, because it is considered key skills, core skills, and basic skills that will foster higher-order thinking skills (Izetbigovic et al., 2019).

The realization of increasing students' understanding of science while participating in learning can be measured by students' basic skills. These basic skills are known as generic science skills. Generic science skills are a combination of scientific knowledge and skills (Khabibah et al., 2017). Indicators of generic science skills include observation, scale awareness, symbolic language, logical inference, the law of cause and effect, the logical framework, logical consistency, modeling, and abstraction (Yohana et al., 2018). Generic science skills can develop if you can build concepts continuously within yourself. Thus, generic skills are mature individual skills (Maknun, 2015). According to Dibyantini & Azaria (2020), students who have generic science skills will be able to make decisions in solving problems from various perspectives in an appropriate, thorough, and logical manner.

In learning Chemistry, it is very important to develop generic science skills. Several previous studies acknowledge that statement. The research conducted by Rosidah et al., (2017), states that generic science skills are needed in understanding chemical concepts and solving problems and scientific activities. Generic science skills must be included in the chemistry education curriculum

(Taber, 2016). One of them is chemical equilibrium material. Chemical equilibrium material needs to give opportunities for students to build their knowledge because the topic is closely related to the phenomena around them (Fassenda & Yonata, 2016).

Conducting an assessment of a student's initial abilities related to generic science skills certainly requires a test instrument because generic science skills are not only developed through the learning process but can also be through appropriate evaluation tests. In line with the research of Ratna (2017), to measure students' generic science skills, an assessment instrument is needed that is easy to use and suitable for measuring generic science skills. In the learning process organized by the teacher, to measure the ability of students to understand the learning, a reliable assessment instrument is needed by the aspects and indicators to be measured. However, based on interviews conducted with the teacher of SMAN 2 Percut Sei Tuan, there are not many test instruments that can be used to measure students' initial abilities based on generic science skills. The teacher's assessment of the student's initial abilities is only through observation not through carrying out tests.

Therefore, to overcome this problem, it is necessary to develop an initial ability instrument that is linked to students' generic science skills. So that the evaluation model that will be developed in this study is multiple-choice. These questions will later be used to analyze students' initial abilities to find out how well students have students' initial abilities because with the right instrument, it is hoped that students will become accustomed to solving questions that hone generic science skills, which will increase their skills.

METHOD

This research uses R & D (Research and Development) method. The purpose of this research is to ensure the feasibility of the initial ability instrument. The product developed was an initial ability test instrument based on generic science skills on chemical equilibrium material in the form of multiple choices and consisting of a scholastic test and a chemistry test. The research subjects were class XI IPA C SMAN 2 Percut Sei Tuan students. This study uses a 4D development model. The 4D development model consists of 4 stages of development, namely: define, design, development, and disseminate (Thiagarajan, 1974). But in this study, only reached the development stage and did not get to the dissemination stage because of the limitation of researchers in various ways, both in terms of manpower, time, and cost then the dissemination is not done by the researcher. The stages in the 4D research model are shown in Figure 1. The research design in Figure 1 is explained in the following procedure: 1) the define stage aims to find problems and requirements in developing initial ability test instruments; 2) the design stage aims to design test instruments. So, researchers find a draft that will be developed; and 3) Development, the researcher develops the instrument, then the instrument will be validated by the expert then they will carry out a revision assessment when the product has been repaired so that it is suitable for use, and trials by deploying the product to test the feasibility of the test instrument.
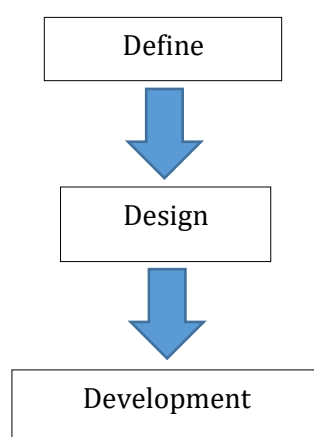

Figure 1. Development stage

From the results of trials that have been implemented on students, validity, reliability, difficulty level, discriminating power and problem deception will be sought. The instruments used were validity questionnaires. The validity questionnaire includes aspects of material, construction, language, and addition. The validation instrument grid shown in Table 1.

Table 1. The validation instrument grid

No.	Aspect	Indicator
1.	Material	1. Item of questions according to the learning objectives
		2. Item of questions using an intesting stimulus
		3. Item on questions using a contextual stimulus (image . graphics, text) as appropriate
		4. Measuring level cognitive Bloom (Remembering, Understanding ,adan applying)
		5. The answers to the questions do not adopt the stimulus from the others
		6. Questions are not routine and bring renewal
		7. The choices of the answer are homogeneous and logical
		8. Each questions has only one correct answer
2.	Construction	9. The item of questions are formulated in briefly, clearly and concisely
		10. The formulation of the item and the choice of the answer is a required statement
		11. The questions do not give clues to the answer key
		12. In the questions images, graphs ,tables, diagram and the like are clear and functional
		13. The questions do not cause multiple interpretations
		14. The answer of the questions do not use the statement all answer is correct and the like
		15. The answer choice in the form of number /time are arranged based on the size of the number or chronology
		16. The answer of the questions does not depend on the previous answer
3.	Language	17. The item of the questions using the good indonesian language
		18. Do not use the language that applies in the local area
		19. The questions using communicative sentences
		20. The language used is in accordance with the level of cognitive development of student
4.	Addition	21. The item of questions do not contain the element of religion, ethnic, rave, intergroup, pornography, politics, propaganda, and violence

The expert validator's assessment of the test instrument uses a Likert scale of 1-5. After obtaining the results of expert validation, it will be calculated using a formula to determine the percentage of validation results for each criterion, as shown in Formula 1. Information: P refers to the validation percentage, SR refers to the total score from expert validation, N refers to the maximum score, and R refers to the number of expert validations.

$$P = \frac{S_R}{N\,R} \text{ X } 100\ \% \tag{1}$$

To find out the validity of the instrument, the results of the percentage form are developed and interpreted based on the score criteria listed in Table 2. Based on the category in Table 2, the initial ability test instrument is said to be valid if the percentage is ≥ 61 %

Table 2. Category validation adopted from Riduwan & Akdon, (2013)

Persentage (%)	Category
0-20	Very invalid
21 – 40	Invalid
41 – 60	Quite valid
61 – 80	Valid
81– 100	Very valid

RESULT

This research intends to find out the feasibility of an initial ability test instrument based on generic science skills which is developed into an assessment instrument capable of measuring students' initial abilities. This study uses a 4-D model, the following describes each stage in detail.

Define

At the define stage, based on the final preliminary analysis, the researcher found that teachers rarely carry out initial ability tests in learning activities and there is still a lack of availability of test instruments that can be used to analyze students' initial abilities. Student analysis, based on learning in schools at this time needs to increase students' higher-order thinking skills (HOTS) but the fact most students still have low higher-order thinking skills, one of the reasons is because students are not ready to take part in lessons because they do not have initial abilities. Material analysis, to examine the material to be used by learning. Task analysis by analyzing basic competencies by the K13 curriculum associated with generic science skills in students.

Design

At the design stage, the researcher determines the design of the test instrument on the needs that will be developed starting from determining the purpose of the instrument, namely measuring students' initial abilities, the form of the instrument in the form of multiple choice written test consisting of a scholastic test and a chemistry test, compiling a grid of questions so that the questions distributed maracas and used as a reference for writing questions that were adapted to the sub-topic of the material and indicators of generic science skills and design of test instruments consisting of writing questions according to the question grid with the show in Table 3, instructions for working on questions, scoring instructions and making validation sheets.

Table 3. Grid of the initial ability test instrument

Sub Topics	Indicators of GSS	Learning Objectives	Scholactic Test	Chemistry Test
Definition of Chemical Equilibrium	1. Logical framework 2. Indirect observation	1. Students can explain the concept of Equilibrium (reversible and irreversible reactions)	1, 2, 3, 4	1, 2, 3, 4
		2. Students can explain homogeneous and heterogeneous equilibrium	5, 6	5, 6
		3. Students can explain the characteristics of dynamic equilibrium	7, 8	7, 8
Shifts direction of chemical equilibrium	1. Abstraction 2. Logical framework 3. Concept formation	1. Students can analyze the effect of concentration shifts in equilibrium	9	9
		2. Students can analyze the effect of temperature in shift Equilibrium	10, 11	10, 11
		3. Students can analyze the effect of pressure and volume on shifts in equilibrium	12, 13	12, 13
Chemical Equilibrium Constants	1. Using the symbolic language. 2. Making a mathematical model	1. Students can determine the price of the equilibrium constant based on concentration (KC)	14, 15	14, 15
		2. Students can determine the price of the equilibrium constant based on pressure (KP)	16	16
		3. Students can determine the relationship between KC and KP	17	17
		4. Students can determine the degree of dissociation	18	18
Application Concept of Chemical Equilibrium	1. Logical inference 2. Logical framework	1. Students can analyze the application of daily chemical equilibrium	19	19
		2. Students can analyze the application of chemical equilibrium in the industrial field	20	20

After the test instrument grid is made as shown in Table 1, the questions then be written which consists of 2 parts, namely the scholastic test and the chemistry test. The Scholastic test will support achievement in completing chemistry because the chemistry test is adjusted to the scholastic test. The results of the design stage are initial ability test products which consist of scholastic tests and chemical tests on the topic of chemical equilibrium.

Development

The development stage consists of the expert validation assessment of the initial ability test instruments that have been developed. The expert validation consists of 2 chemistry lecturers and 4 chemistry teachers. Validation is carried out by providing test instruments and validation sheets. The research instrument was an expert validation sheet which was used to obtain information about the expert's assessment of the initial ability instrument, where the expert could write yes/no for each question (Sumarni et al., 2016). The validation sheet given to the expert contains 4 aspects, namely aspects of the material, construction, language, and additional rules. Table 4 presents the results of the initial ability test validation of chemical equilibrium materials by experts.

Table 4. Result validation by expert

No.	Aspects	Average grades
1.	Material	85 %
2.	Construction	83 %
3.	Language	92 %
4.	Addition	100 %
Average		**90 %**

Table 4 shows that the results of the expert's average assessment on material aspects are 85% is obtained in the "Very Valid" category, and then construction aspects 83% is obtained in the "Very Valid" category, the next language aspects are 92% is obtained in the "Very Valid" category, and the last steadfast rules are 100% is obtained in the "Very Valid " category. So the average percentage obtained from the initial ability test validation is 90% in the "Very Valid" category. These results indicate that the initial ability test instrument based on generic science skills is declared feasible for measuring students' initial abilities, especially in chemical equilibrium material. After validation from the validator, the questions that have been revised based on the validator's suggestions will be tested on students to know the feasibility of the initial ability test that was developed. The trial test was carried out on 36 students at SMAN 2 Percut Sei Tuan in class XI IPA C, where students were asked to take an initial ability test with 40 questions consisting of 20 questions on the scholastic test and 20 on the chemistry test. From the results of trials that have been carried out on students, validity, reliability, level of difficulty, discriminating power, and distractor questions will be sought.

Validity

Validity relates to the ability to measure exactly what is desired to be measured (Purwanto, 2014). In this study, the item analysis of validity was tested with a significance level of 5%, so because the number (N) was 36 students, the r table is 0.329. The item is said to be valid if the r xy > r table, while invalid if the r xy < r table. The results of the item validity analysis on the initial ability test that developed can see in Figure 2. Based on the data in the Figure 2, it is known that the validity of the initial ability test consisting of a scholastic test and a chemistry test. The results of the scholastic test from 20 questions developed, the results obtained were 18 valid questions with a percentage of 90% and 2 questions were declared invalid. While for the test chemistry of the 20 questions developed resulted in 17 valid questions with a percentage of 85% and 3 invalid questions with a percentage of 15%.
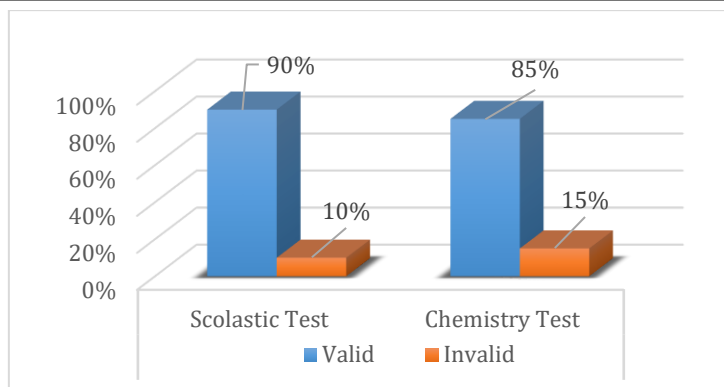
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Figure 2. The initial ability test validation

Reliability

Reliability is the accuracy and constancy of measurement results, a test instrument has an adequate level of reliability if when the test instrument is used it gives consistent results (Sukmadinata, 2017). The reliability of a test instrument is symbolized by r_{11}, which ranges from 0.0 to 1.0. Reliability analysis is used only for items that have met the validity requirements. Test reliability in this study used the *Kuder Richardson (KR 21)*

To interpret the reliability value of the test instrument adjusted to the critical table f Product moment table with α= 0.05 and N= 36, r table = 0.329 is obtained with the criterion r 11> r table for the real level declared reliable. In the scholastic test reliability test, out of 18 valid questions using the KR 21 formula, the r11= 0.801 was obtained, where r table = 0.329. By comparing the value of r 11 and r table, it can be determined the reliability of the test items with the criterion r 11 > r table or 0.801 > 0.329, it is stated that all the items on the scholastic test are reliable and in the high-reliability category.

Meanwhile, in the chemical test reliability test of 17 valid questions using the KR 21 formula, the value of r 11= 0.814 was obtained, where r table= 0.329. By comparing the value of r 11 and r table, it can be determined the reliability of the test items with the criterion r 11 > r table or 0.814 > 0.329, The items on the chemistry test are reliable and the reliability category is very high.

Difficult Level

Difficulty level analysis was carried out to analyze whether the questions were classified as easy, medium, or difficult. A good test instrument should be neither too difficult nor too easy (Silitonga, 2014). The results of the analysis of the difficulty level of the initial ability test instrument can be seen in Figure 3. Based on the data in Figure 3, the results of the difficulty level on the scholastic test items show that out of 20 questions, 9 questions are classified as easy with a percentage of 55%, and 11 questions that are classified as moderate with a percentage of 45%. While the results of the difficulty level on the chemistry test items show that of 20 questions, 4 questions are relatively easy with a percentage of 30% and 16 questions that are classified as moderate with a percentage of 70%.
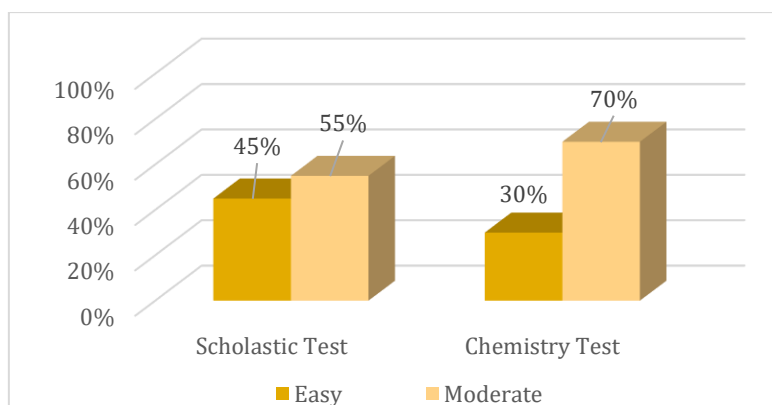

Figure 3. The initial ability test difficulty level

Differential Power

The differential power of the items is the ability of an item to map students with high and low abilities (Nana, 2017). Items are good if the smallest discriminating power is 0.2. The results of the analysis of the discriminating power of the initial ability test instrument is in Figure 4. Based on the data in Figure 4, the results of the initial ability test discriminant obtained that out of the 20 scholastic test items developed, 8 items had good discriminating power with a percentage of 40% and 12 items had fairly good discriminating power with a percentage of 60%. The results obtained for the chemistry test items were also the same, where 8 items had good discriminating power with a percentage of 40% and 12 items that had fairly good discriminating power with a percentage of 60%.

Distractor

The purpose of the distractor on the test instrument is to trick those who are less able or do not know to be distinguished from students who can answer the questions. The distractor or distractor is obtained by counting the number of participants who choose answers outside of the answer key (Silitonga, 2014). The results of the analysis of the distractor of the initial ability test instrument are in Figure 5. Based on the data in Figure 5, In the scholastic test and chemistry test consisted of 20 questions and each question had 5 options consisting of 1 answer option and 4 distractor/distractor options. In the scholastic test, the result shows that 3 distractors need to be revised with a percentage of 15 %, and 17 distractors were accepted with a percentage of 85%. Meanwhile, in the chemical test instrument, the results showed that 4 distractors needed to be revised with a percentage of 20%, and 16 distractors were accepted with a percentage of 80%.
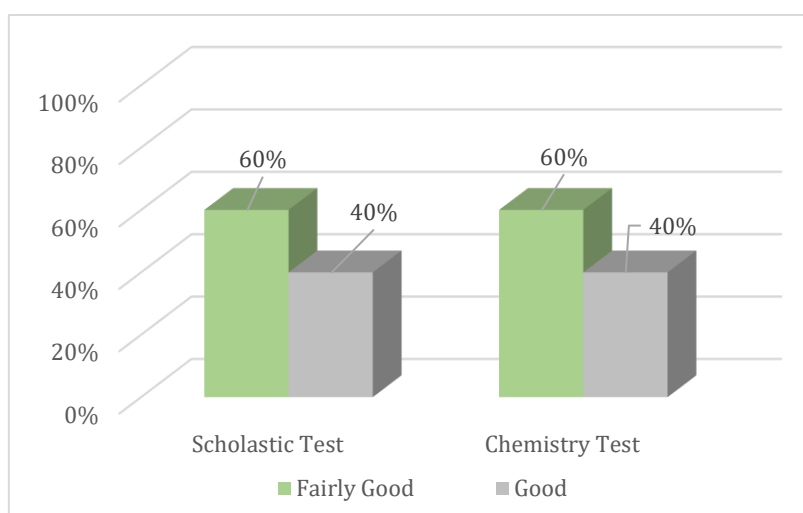

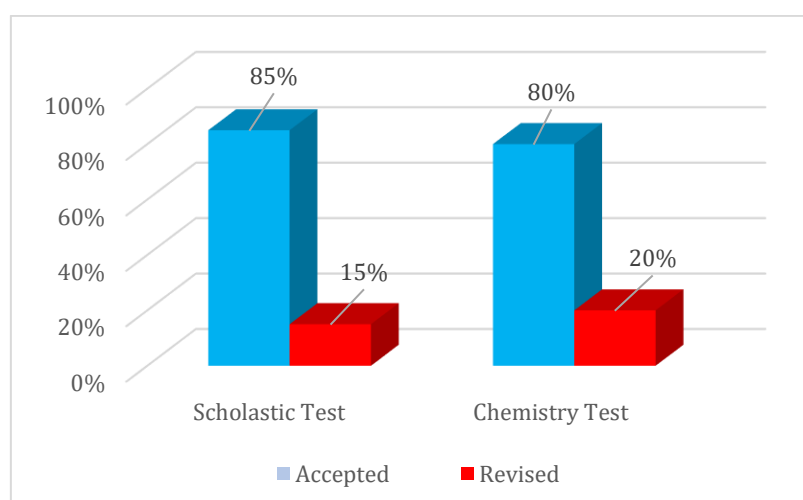**Figure 4. The initial ability test different power**

Figure 5. The distractor initial ability test

DISCUSSION

Based on the research that has been carried out, the results of the development are in the form of a test instrument for students' initial abilities in chemical equilibrium for class XI students. The development research model that the researcher uses is the 4D development research model, which includes the define stage, design stage, and develop and disseminate stage. The instrument used to measure the initial abilities of Class XI SMA students is in the form of a multiple-choice objective test. The student's initial ability test instrument was prepared based on the learning objectives contained in high school chemical equilibrium material and adjusted to indicators of generic science skills because by having some of those skills, students would more easily understand the lesson. By the research of Izetbigovic et al.,(2019), by having generic science skills students can easily learn and understand chemical concepts. In education, generic science skills are one of the important basic skills (Mustofa et al., 2018).

In this research, the student's initial ability test instrument was produced consisting of a scholastic test and a chemistry test. The Scholastic test will support achievement in completing the chemistry test because the chemistry test is adjusted to the scholastic test, while the number of multiple-choice questions produced is 40 questions. For each item, there are 5 alternative answers that students can choose from. It is based on the advantages possessed by the form of multiple choice questions, namely having high objectivity, ease to analyze the results, ease to use in the field,the wide range of material and skills (Prayitno, 2022).

The initial ability test instrument will then be validated by expert validation for content validity tests carried out by 2 doses of chemistry and 4 chemistry teachers as assessors for the appropriateness test of the questions to be used. According to Sugiyono, (2017), the validator's assessment may be without revision, there is a revision and a complete overhaul. These results indicate that the initial ability test instrument based on generic science skills is declared feasible for measuring students' initial abilities, especially in chemical equilibrium material. This is by the research of Laksono (2018) which shows that before carrying out the analysis of the items through field tests, it is better if the items are first analyzed based on the results of expert validation because this has the aim of seeing the quality of the initial product from the initial ability questions which are then refined based on input and suggestions from the assessment results.

The next stage is the trial phase to see the feasibility of the developed test instrument. This is in line with the research of Imania & Bariah (2019), the instruments must have certain qualifications that meet scientific requirements to be suitable for use which can be obtained after conducting trials The trial test was carried out on 36 students at SMAN 2 Percut Sei Tuan in class XI IPA C. After the trial phase was carried out, the researcher then carried out an analysis of each item answered by students by calculating the validity, the reliability, the different power, the difficulty level, and the distractor of the item. Based on the result of test conducted by students, it was found that the initial ability test instrument consisting of a scholastic test and a chemistry test was declared feasible.

On the development of this student's initial ability test, after the test process and feasibility analysis that has been carried out, such as conducting validation tests with experts, validity, reliability, the level of difficulty, power differences, and distractors can be stated that his initial ability test instrument is effective and appropriate for use in the learning process which can be used as a tool to measure initial abilities and improve generic science skills in students in learning chemistry, especially in chemical equilibrium material. The teacher can take advantage of this initial ability test to measure student's initial abilities and can determine the right strategy in learning that is adapted to student's initial abilities.

CONCLUSION

Instruments for students' initial abilities test were developed consisting of scholastic tests in the form of verbal and numerical reasoning tests and chemistry tests as an evaluation of learning outcomes compiled with the 4D development model. The student's initial ability test instrument is adjusted to the generic science skills indicator on the learning objectives of chemical equilibrium material. The initial ability test instrument in the constitute of a scholastic test can support the achievement of a learning achievement evaluation test (Chemistry) in each chemical equilibrium sub-subject matter because the two tests developed are related to one another. The initial ability test instrument based on generic science skills that was developed has fulfilled the feasibility of content validity and construction validity and feasible to use to measure students' initial abilities. As for the limitations of this research, this research did not reach the disseminated stage. Therefore, the other researchers can use this initial ability test to measure students' initial abilities, especially in chemical equilibrium material. For the next researchers can also develop student's initial ability test on other materials.

Author contributions

The authors made significant contributions to the study's conception and design. The authors were in charge of data analysis, interpretation, and discussion of results. The final manuscript was read and approved by the authors.

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Conflict of interest

The authors declare that there is no potential conflict of interest.

Data availability statement

All data are available from the authors.

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