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Validity of Research-Oriented General Physiology Learning Tools to Support Science Process Skills

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Abstract

Students apply the science process skills to investigate scientific phenomena like scientists taught by science teachers who are committed and master the material, structure, and scientific methodology. The general physiology course equips animal and plant physiology knowledge in between science process skills as future junior high school science teachers. The course learning tool must attend to the demands. Research-based learning oriented to scientific processes can train science education students' science process skills. This study aimed to define the validity of research-oriented general physiology learning tools developed to support science process skills. Component learning tools are semester learning plans, textbooks, and assessment instruments. The validation of research-oriented general physiology learning tools developed to support science process skills rated 82.80% with a high category. The category shows that learning tools are worthy of empirical testing.

Keywords: Learning Tools, General Physiology, Research-Oriented, Science Process Skills

INTRODUCTION

Natural Sciences consist of the disciplines of biology, chemistry, and physics, which explain natural phenomena using the scientific method (Schlagwein, 2021). The scientific method shows science as a research process about the natural phenomenon that uses specific skills (ŞAŞMAZÖREN et al., 2022). Skills needed in the research process are science process skills (Beichumila et al., 2022; Bulent, 2015).

Natural sciences learning is included at the junior high school level, ideally not about memorizing knowledge but the research process using science process skills (Pursitasari et al., 2019). Science process skills are the basis for making rational and correct decisions about controversial issues in social life (Ekici & Erdem, 2020). Science process skills are used as the basis for making logical decisions because seen as a problem-solving skill, realized by a systematic process to find solutions (Rauf et al., 2013).

Scientific methods that use Science process skills in learning natural sciences takes a relatively long time (Duruk et al., 2016). Natural science teachers who are committed and master the material, structure, and scientific methodology can apply it (Ioannidou et al., 2022; Lotter et al., 2018; Mumba et al., 2018). Natural Science teachers with these characteristics also help students have science process skills to investigate scientific phenomena like scientists (Molefe & Aubin, 2021). That means natural science teacher influences ideal natural science learning in junior high school (Macanas & Rogayan, 2019; Mushani, 2021).

General physiology course equips science process skills' science education students as future junior high school science teachers. General physiology discusses the physiology of animals and plants and explains scientific phenomena in daily life-related physiology concepts (Duda & Newcombe, 2019). Observation results obtained information the general physiology course learning uses discourse method. The method differs from science as a research process on natural phenomena because it places students as passive learners without using science process skills. Science education students who are not trained in science process skills show that the learning tools aren't optimal.

Pedagogically science learning that places students as passive learners is called the deductive approach (Khan et

al., 2020). The pedagogical approach provides opportunities for students through all processes called the inductive approach (Constantinou et al., 2018). A pedagogical approach through a series of processes is most suitable applied because a series of processes develop science process skills' students (Baydere et al., 2020). General physiology learning tools can improve by developing them based on a process approach. These improvements are expected to develop science education students' science process skills.

science process skills start from observation skills and is arranged hierarchically and following the mindset of scientists when producing information (Ekici & Erdem, 2020). Pedagogically inquiry-based learning places students in similar activities to scientists to build their knowledge (Pedaste et al., 2015). Science process skills can facilitate inquiry-based learning because they have the same focus by placing students who study science as scientists.

Several studies on inquiry-based learning have proven to train and even improve the science process skills of students or prospective science teachers. The results of Yakar & Baykara's (2014) research explain that identified variables as science process skills and very important when designing investigations increased, which caused inquiry-based learning triggers high curiosity among pre-service science teachers to create discussions about a problem and guide the search for a solution. The results of ŞEN & VEKLİ (2016) research explain pre-service science teachers' science process skills increases in 5 skills (determining and examining variables, making definitions according to what have done, hypotheses, analyzing data, and creating graphs, designing experiments), that increase because pre-service science teachers make investigations design by independently so that they trained to gain knowledge like scientists.

Inquiry-based learning has popularity in international education research and development because success increases according to technical advances (Pedaste et al., 2015; West et al., 2020). Inquiry-small research or research-oriented learning is the development of inquiry-based learning that prioritizes independence in finding knowledge. Research-oriented learning consists of activities series that mobilize all students' abilities to solve scientific problems or phenomena using systematic steps and require students to build their knowledge (Yuhanna et al., 2017).

The characteristics of inquiry-small research are per the demands of

general physiology courses to master the physiology of animal and plant bodies and explain scientific phenomena in everyday life related to physiological concepts through investigations to train science process skills, that condition render to develop general physiology learning tools. Aims research to define the validity of research-oriented general physiology learning tools developed to support science process skills.

METHOD

Research-oriented general physiology learning tools developed to support science process skills developed at the Science Education Study Program, Faculty of Teacher Training and Education, at a public university in Banten, Indonesia. The method used is research and development. Research and Development (R & D) is a series of processes in developing and validating educational products such as teaching materials, media, learning models, and so on (Borg & Gall, 1983).

The R & D model used the ten stages procedural model from Borg & Gall (1983). The use of Borg & Gall's (1983) procedural model is limited to the third stage, namely: (1) research and information gathering; (2) planning; and (3) initial product development and validation by experts. R & D is limited to the third stage because the research purpose is a validity category, criticism, and suggestions on the learning tools developed. This limitation is per the explanation of Taufik et al. (2021) that expert validation needs to assess, review, and provide criticism and suggestions to improve the quality of learning products developed before being tested.

The validity category, criticism, and suggestions get from one learning assessment expert from a public university in Riau-Indonesia, two material experts, and one learning media expert from a public university in Banten-Indonesia. The experts use a validation sheet in the form of a questionnaire to assess the learning tools developed.

The validation sheet used by the experts produces research data. Critique and suggestions from experts as research data is analyzed to obtain consideration for revision. Aminullah & Masnur (2019) analyze stage use to find the validity category. That stages process scores to find validity categories. The first stage is recapitulation expert's assessment, the second stage score is calculated from every aspect to find the average, and the third stage determines the validity category by a score calculated before being rated using numbers interpreted qualitatively. Table

1 is presented a list of validity categories according to Sudijono (2017).

Table 1. The Validity Category of Learning Tools Development (Sudijono, 2017)

Score (%)	Category
$81.25 < x \leq 100$	Very Valid
$62.50 < x \leq 81.25$	Valid
$43.75 < x \leq 62.50$	Not Valid
$25 < x \leq 43.75$	Invalid

RESULTS AND DISCUSSION

The procedural stages of R & D used in developing research-oriented general physiology learning tools to support science process skills, which aims to obtain validity categories as well as criticisms and suggestions for these learning tools presented in the following explanation.

1. Research and Information Collecting

Determination of learning tools as educational products develop to solve problems carried out at the research and information-collecting stage. According to Borg & Gall (1983), the research and information-gathering stages are through needs analysis, literature review, and small-scale research. The development of learning tools is determined based on data from observations during the general physiology course. A literature review accompanied this stage.

The research and information collecting stages obtained the results that during the learning of general physiology subjects use discourse methods. That method is contrary to science as a research process on natural phenomena because it places students as learners who only receive material without using science process skills. The situation of students in science education not trained in science process skills shows the learning tools designed are not optimal, so a research-based general physiology learning tool is developed to support science process skills consisting of lesson plans, textbooks, and assessment instruments.

The components of the learning tools are by the Guidelines for Preparing the Higher Education Curriculum by Juanaidi et al. (2020) regulate learning tools least consisting of semester lesson plans, learning materials, and media in the form of textbooks, assessment, and evaluation instruments.

2. Planning

The design of learning tools is the result of the planning stage. Learning tools designed for product development at least contain the intent of the product, product users, exposure to product components, and usage (Borg & Gall, 1983). The results of the planning stage are three components of storyboards of learning tools such as semester lesson plans, textbooks, and assessment instruments.

Storyboard general physiology semester lesson plan as the initial design contains (1) general physiology course identity; (2) study program learning achievement of Science Educators including attitudes, general and specific skills, and knowledge; (3) learning achievement of general physiology course program which is derivative of study program learning achievement; (4) description of the general physiology course containing the scope of the material; (5) study materials contain the concept of general physiology courses; (6) learning media; (7) references used; (8) semester lesson plans for physiology course for 16 meetings in one semester which describes learning indicators, sub learning achievement of the course program, criteria, and forms of assessment, research-oriented learning form, and weight of assessment in percentage form. The semester lesson plans will be printed in form using an A4 paper format.

Orientation of storyboard semester's lesson plans to Outcome Based Education (OBE) emphasizes students' achievements at the end of the learning experience. Implement OBE through student-centered learning, competitive assessment, and the teacher as a facilitator to build knowledge and students' skills (Ag Damit et al., 2021; Priya Vaijayanthi & Raja Murugadoss, 2019). The results structure manages all educational activities, and their evaluation is carried out according to clearly defined criteria at the outset (Ping, 2020; Yang & Fan, 2022). science process skills are student achievement facilitated by OBE. Research-oriented learning ensures students gain experience from OBE.

Storyboard general physiology textbook as initial design contains three main components. There are three components: (1) the opening component consisting of the title page, user manual, table of contents, pictures list, and introduction; (2) the content component contains research-oriented topics that must be allowed as a general physiology learning process; (3) closing component consisting of bibliography and author biodata. Textbooks will be developed in print and electronic form using A5 paper format.

The content component that contains Research-oriented learning topics begins with the presentation of basic concepts of general physiology supported by illustrations as a provision of knowledge, then is presented through research-oriented learning instructional steps according to Yuhanna et al. (2017), namely formulating problems, proposing hypotheses, conducting experiments, recording experimental results, processing data, analyzing and

concluding based on scientific attitudes such as honesty, tolerance, perseverance, optimism, cooperation, and high curiosity. Research-oriented learning is a learning process expected to develop science process skills' students and used as a tool to study general physiology knowledge or content.

The assessment instrument will develop as a subjective test, namely an open-ended description question to measure the science process skills' students after participating in a research-oriented general physiology learning process. A question grid must be there before developing open-ended questions as a question guide. The question grid is a storyboard or initial design of the assessment instrument. The question grid needs to be built precisely so that the question product has a level of difficulty, depth, and breadth of material by the learning indicators.

3. Early Product Development and Expert Validation

The development of educational products is based on the design in the previous stage and through expert desk evaluation to get analysis and logical considerations for product improvement carried out in the initial product development stage (Borg & Gall, 1983). This stage produces a research-oriented general physiology learning tool to support science process skills according to a storyboard made. Learning tools consisting of lesson plans, textbooks, and assessment instruments were evaluated through validation by experts to obtain categories of validity as well as criticism and suggestions.

Validity category based on expert assessment of the learning tools developed provides necessary information because it shows readiness tested (Kurniasih et al., 2022; Prasetyaningsih et al., 2022). A high level of validity means learning tools are ready to be tested (Khozaei et al., 2011; MacLeod et al., 2018). Table 2 presents expert validation results of learning tools.

Table 2. The Results of The Validation of Learning Tools

No.	Learning Tool Components	Percentage	Category
1	Semester Learning Plans	77.8%	Valid
2	Textbooks	88.5%	Very Valid
3	Assessment Instrument	75%	Valid
	Total	82.8%	Very Valid

The results of the validation of each component of the learning device in Table 2 obtained different percentage values. Semester lesson plans and assessment instruments are classified as valid, while textbooks classify as very valid. 82.80% is the average percentage

value of learning tools validation who placed learning tools have a decent category. Overall validation results show that research-oriented general physiology learning tools to support science process skills are worthy of small-scale field trials at the research and development stage in the future. The following interpretation validity results of research-oriented general physiology learning tools to support science process skills' science education students are:

a. Semester Learning Plans Validity

Semester learning plans based on Table 2 obtained a percentage value of 77.8% as valid. Validity results from the expert showed semester learning plans developed to match with Guidelines for Preparing the Higher Education Curriculum by Juanaidi et al. (2020) and oriented by OBE emphasize student achievements and getting learning experience. This conformity by the general physiology sub-learning achievement is the final ability possessed by students following research-oriented learning so that it can improve science process skills. The list of learning materials and resources supports the achievement of learning indicators and follows current scientific developments.

Although the experts gave a valid category assessment of the developed semester lesson plans, the experts also provided criticism and suggestions for revision. Critics and suggestions experts are the criteria and forms of learning assessment in the semester learning plan do not fully measure the research-oriented learning aiming to improve science process skills. Research-oriented lesson plans do not fully measure science process skills because the proportion of assessments for each task listed in the semester lesson plan is unclear. Exams in the middle and end assessments need to be clarified.

Revision to fixing learning plans is to make assessment information very clear and transparent. Assessment proportions every task presented in learning plans. This revision, according to Siregar (2020), Hagen (2020), and McCarthy et al. (2022), explains every task given to students needs to include the type, process, report systematics, indicators, and proportion to improve the quality of students.

b. Textbooks Validity

Textbooks based on Table 2 obtained a validity percentage value of 88.5% as a high category. Validity results showed development obeys storyboards made before. Validity results also showed graphically designed according to the scope of general physiology courses. The layout attracts students to read because objects such as

pictures and tables are balanced the view does not interfere.

The basic concepts of general physiology supported by image as a provider of knowledge are presented in full and according to the breadth and depth material. The same opinion about images as graphic components provides a message expressed by Cheng et al. (2022) that visual design, especially abstract graphics, is an overview figure that attracts potential readers and visually summarizes what the paper is about.

Presented general physiology material through research-oriented instructional steps, namely formulating problems, proposing hypotheses, conducting experiments, recording experimental results, processing data, analyzing, and concluding based on scientific attitudes such as honesty, tolerance, perseverance, optimism, cooperation, sense of belonging and curiosity can trigger an increase in science process skills' students. Bravo et al. (2016) explain that science process skills can improve by using textbooks to fulfill their role and function as a learning process if knowledge and activities as a form of learning activities combined. The same argument by BAŞKAN TAKAOĞLU (2017) textbooks facilitates learning programs designed by the lecturer using an approach or method so students not only focus on memorizing knowledge but also carry out process-oriented projects or performance tasks.

Although the textbook's validity results from experts as a high category, the experts also provided criticism and suggestions for revision. Experts critique and suggest that it is necessary to add scientific phenomena that occur in everyday life. Scientific phenomena in daily life make learning contextual and meaningful learning.

The revision was to add scientific phenomena at the beginning related to small scale topics of general physiology research. This revision is based on the argument of Harlow et al. (2020) and Lago & Cruz (2021) that a crucial element of contextual learning material that makes it meaningful is related to experiences or phenomena in one's daily life or pre-existing knowledge. The addition of scientific phenomena that occur in everyday life conveys Whitesides (2018) and Kibga et al. (2021) also plays a role in triggering curiosity that affects science process skills, namely asking questions.

c. Assessment Instrument Validity

The assessment instrument based on Table 2 obtained a percentage value of 75% as valid. Validity results mean developing an assessment instrument subjective test is an open-ended

description that exists following the learning outcomes of the general physiology course. The test materials are from relevant sources, so there is no doubt that it is theoretically and empirically correct. Explanatory objects equip the test, case examples, and library references to help students understand them.

Science process skills' students after participating in research-oriented learning suitable, measured by the subjective test is an open-ended description question as an assessment instrument. Justified suitability by the explanation of Solé-Llussà et al. (2021) and Zu *et al*. (2021) in the form of open-ended description questions forcing students to rely on their skills for introspection of the process carried out so that what is measured is science process skills. The same argument conveyed by Chiu & Lin (2019) and Polat (2020) is that open-ended questions require students to construct knowledge from a series of scientific processes.

Although the assessment instrument validity result from the expert is valid, the expert also provides criticism and suggestions for revision. Expert critique and recommendation are to correct the contradictions between the indicators and science process skills to be measured. The contradictions shown by indicator questions require students to explain with intention hypothesis as science process skills to be measured. Revise contradiction by switching the measured science process skills into communicating skills.

Revision to fixing contradictive between question indicator and intention measured science process skills based on Martin's explanation (2020) that the specification of questions such as indicators and questions must be appropriate to the skills measured, which aims to maintain the accuracy of the assessment instrument will later be used as a guide for improving the learning process. A good set of indicators and questions can be a functional tool for process monitoring, comparison, and estimate of learning outcomes to achieve specific goals (Aihara, 2016; Bucur et al., 2018).

CONCLUSION

The validity of research-oriented general physiology learning tools to support science process skills rated 82.80% with a high category. The category shows that learning tools are worthy of empirical testing.

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