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Development of Computer-Based Assessment Instruments Nuclear Physics Introduction Course as An Effort to Grade Authentically

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Abstract: The introductory course of nuclear physics in the physics education study program is carried out online, hybrid, and offline by providing teaching materials in the form of digital handouts equipped with videos to add explanations. The use of technology has been used as a learning evaluation tool, both to evaluate practice questions or official ones such as Quizizz, web-based, google form and form facade. This research is about the development of the Visscher-Voerman procedure which consists of Nature of analysis activities, Design (The shaping of the solution, Design (Media Selection), Design (Starting from target group instead of subject of matter), Evaluation (The use of formative evaluation) and Implementation and formative evaluation using Tessmer's evaluation stages: self-evaluation, expert review, one-to-one evaluation, small group evaluation and field test. The result of this research is a product in the form of a computer-based assessment instrument on nuclear physics introduction course that have met the validity criteria, reliable and practical, so that it can be used as a learning evaluation tool. The validity of the instrument was obtained from three lecturer reviewers in the content, construction, language and application sections with the respective results of 4.73 (very valid), 4.80 (very valid), 4.78 (very valid) and 4.58 (valid). Reliability of the instrument was tested with the help of SPSS version 22.0 for windows, by carried out simultaneously on all item items by looking at the Cronbach's alpha value for the midterm and final semester exams. The reliability results respectively are 0.82 with 25 items and 0.85 with 35 items included. It's mean that they are in the reliable categories. Product practicality test was carried out on October 14 -15 2022 and continued on May 5 2023. The respondents are FKIP Physics UNSRI's student class of 2019-2020, with one-to-one (3 students) trials, small group trials (10 students), and wide trials (36 students). The results are respectively 3.81, 3.89 and 3.72 with a very practical category.

Keywords: Assessment instruments; Computer-based; Development; Nuclear physics introduction

Introduction

Introduction to nuclear physics is part of nuclear physics. The description of this course is advanced knowledge of Modern Physics material whose study focuses on atomic nucleus material. Nuclear physics introduction lectures in the physics education study program FKIP Sriwijaya University are held online, hybrid and offline with the help of teaching materials developed in the form of digital handouts equipped with videos to make it easier for students to understand the material and carry out online learning (Murniati et al., 2022). The development of teaching materials by lecturers can make it easier for students to study independently.

Many studies that provide teaching materials have been carried out, including by Astuti et al. (2014), and Riandry et al. (2017). Online lectures using digital

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handouts that are valid and practical have a positive impact on the success rate of learning process in students (Murniati et al., 2022). The evaluation process for online, hybrid and offline learning can be done in various forms of computer-assisted questions by using various applications. The use of essay type questions in online and hybrid lectures has faced with many obstacles and weaknesses, both in terms of monitoring and in terms of correcting them which takes quite a long time and has a high level of subjectivity. While the multiple choices type of question has a high element of objectivity, but the element of guessing the answer is also high, therefore it is necessary to develop a form of computer-based multiple choices test that is valid, reliable and practical by utilizing technology.

Technology has been used as a learning evaluation tool, both evaluating practice questions or being official (Imania & Bariah, 2019). Conducting assessment evaluation tests there are several applications used by Quizizz (Hamidah & Wulandari, 2021; Nazhifah et al., 2021), Kahoot as an evaluation tool (Daryanes & Ririen, 2020), Web-based online learning evaluation (Zahara, 2015). Based on this, we developed a computer-based evaluation tool for nuclear physics introduction material using the form facade application in the physics education study program, FKIP, Sriwijaya University, Palembang.

Physics is a part of science that deals with how to know about natural phenomena systematically, so that the learning process is not just collecting of knowledge in the form of facts, concepts or principles but also the process of discovering (Niniati et al., 2020). The field of physics is divided into classical physics, which includes motion, fluids, heat, sound, light, electricity, and magnetism, modern physics, namely relativity, atomic structure, quantum theory, condensed matter, nuclear physics, particle physics, cosmology, and astrophysics (Giancoli, 2001). Nuclear physics is a branch of physics that studies the structure of the atomic nucleus and the interactions that occur from its constituents. The study of nuclear physics begins with the discovery of radioactivity which shows the spontaneous release of particles or energy from radioactive matter, the discussion of nuclear physics continues to develop which focuses on the forces forming the nucleus and systems of many particles (Muslim, 1994).

The nuclear physics assessment process is the same as other materials, in the context of learning assessment means collecting various information about student learning processes and outcomes in order to determine decisions that need to be made in learning (Anderson, 2003), Propham (1995) states several reasons for the importance of understanding and implementing assessments, including: Assessment is a tool for diagnosing students' strengths and weaknesses in the learning process; Assessment is useful for monitoring student progress; Assessment helps determine the level of students; Assessment can also determine the effectiveness of learning that has been designed; Assessment can also improve the quality of learning.

Various forms of assessment tools that can be used in the learning process such as multiple choices questions, essays, short answers, true-false and matching. The development of multiple choices items by optimizing distractors has received a lot of attention related to detection of student weaknesses and strengths. The technique used is to choose distractors that represent common mistakes that are often made by students. The use of multiple choices tests with significant distractors to obtain reports on students' understanding levels has been implemented for mathematics and language subjects (Kusairi, 2013). The development of multiple choices items with meaningful distractors has great potential to help teachers obtain information on weaknesses and students' strength in learning the concept. Good multiple choices questions need to be tested for validity.

The definition of validity according to Alihar (2018) are functions to measure the extent to which the level of accuracy and precision in both test and non-test. If the results obtained are in accordance with the theory, then the measuring instrument can be said to be included in the valid category.

The computer-based test is an exam system that utilizes computer technology as a test medium. Suyoso et al. (2017) states that computerized based tests have several advantages, including: reducing time for test assessment work and making written reports, eliminating logistical work such as distributing, storing tests using paper. Student results can be seen immediately after the assessment is carried out thereby reducing the teacher's burden in correcting students' answers. Based on the research of Özden et al. (2004) students gave positive responses to computer-based tests, computer-based tests are also accurate for measuring test takers with moderate to high abilities (Santoso, 2010).

Method

Based on Van Den Akker (1999) the purpose of development research can be seen from various viewpoints that cannot be separated. According to Saputro (2017) the research & development method is a research method that produces a product in the form of a model, module or something else, and there is effectiveness of the said product. The development procedure used in this study is the Visscher-Voerman

(1999) procedure which consists of Analysis (Nature of analysis activities), Design (The shaping of the solution), Design (Media Selection), Design (Starting from target group instead of subject of matter), Evaluation (The use of formative evaluation) and Implementation.

Research *Flow*

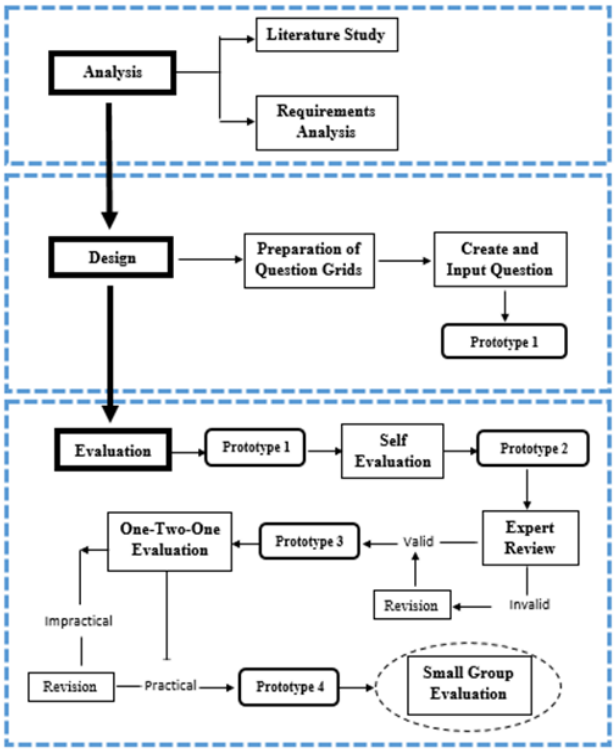

Figure 1. Research flow

Data Collection Technique

Data on the validity of the assessment instrument was obtained by providing questionnaire to the reviewer in the form of expert in the subjects, construction, language and application. Data to determine the reliability and practicality of the instrument was obtained by testing it on the students.

Data Analysis Techniques

Instrument validity analysis was carried out in a qualitative descriptive manner by changing the review in qualitative form to quantitative form with the provisions in the following table 1.

Table 1. Answer Categories and Scale (Nazhifah, 2021)

Answer Category	Scale
Perfect fit	5
In accordance	4
Just Appropriate	3
Less Appropriate	2
is not in accordance	1

The validation results are processed using the following equation 1.

$$V_a = \frac{\sum_{i=1}^{n} A_i}{n} \quad (1)$$

Information:

V_a = value for each statement

$\sum_{i=1}^{n} A_i$ = total score of al lstatements

n = number of validators

The value of the validator results will be communicated with table 2.

Table 2. Validity Categories (Nazhifah, 2021)

Validity category	Value
Very Valid	4.61-5.00
Valid	3.61-4.60
Valid Enough	2.61-3.60
Invalid	1.61-2.60
Totally Invalid	1.00-1.60

An analysis of the practicality of the instrument was carried out by testing it at the one-to-one evaluation and small group evaluation stages by asking students to fill out a questionnaire and provide suggestions. The assessment criteria refer to table 3.

Table 3. Assessment Criteria (Nazhifah, 2021)

Answer Category	Scale
Strongly agree	4
Agree	3
Don't agree	2
Strongly Disagree	1

$$R = \frac{\sum_{i=1}^{n} V_i}{n} \quad (2)$$

Information

V_i = valueforeachstatement

$\sum_{i=1}^{n} V_i$ = the total scoreof all students

n = lotsof data

After being analyzed, the average value results are obtained which will then be communicated in table 4.

Table 4. Practicality Level Categories (Nazhifah, 2021)

Value	Practicality level
3.26-4.00	Very Practical
2.51-3.25	Practical
1.76-2.50	Impractical
1.00-1.75	Very Impractical

Data Reliability Test

Instrument reliability analysis was carried out by testing the score of the evaluation test results for reliability using the help of SPSS software version 22.0 by looking at the Cronbach's alpha value. According to (Hidayat, 2021).

Table 5. Reliability Criteria (Christine, 2021)

Cronbach'salpha	Criteria
0.00– 0.20	Very low
0.21– 0.40	Low
0.41– 0.60	Enough
0.61– 0.80	high
0.81–1.00	Very high

According to Sujarweni (2014) if the Cronbach's alpha value is > 0.6 the instrument is declared reliable or consistent and if the Cronbach's alpha value is <0.6 the instrument is declared unreliable or inconsistent.

Results and Discussion

Results of the Needs Analysis Phase

Based on the student responses to the questionnaire, regarding the development of computer-based assessment instruments, as many as 64 physics education students who had contracted the nuclear physics introduction course informed 84.3% that they really needed computer-based assessment instruments, 94.1% wanted a computer-based assessment system rather than writing, and 98% of students agree that the current assessment system has not been able to minimize the level of cheating the test. Based on these information, the researcher developed a computer-based assessment instrument for nuclear physics introduction courses that is valid, reliable, and practical to use.

Product Design Results

This stage begins with compiling a grid of questions that will be developed and adapted in line with learning objectives that have been formulated in the Semester Lecture Plan, so that the questions prepared represent each material being studied from various levels of difficulty starting from the level of knowledge, understanding, application, analysis so that 30 the midterm questions and 25 the final semester exams questions are prepared as the initial product, that had been taken from teaching materials and students source books, which will be inputed into the selected Computer Based Test Application.

Results of Self-Evaluation

The initial product (prototype 1) was an computer-based nuclear physics introduction instrument which originally have 30 objective questions for midterm and final semester exams, after being reconsidered based on the distribution of the materials and the effective time of the students working time. It became the reasons to change the total of questions in the midterm (25 questions) and final semester exams (35 questions).

Expert Evaluation Results

Expert review have been conducted by three lecturers of the FKIP Unsri physics education study program to determine the suitability of the material, construction, language, and application of the instrument with the test item indicators.

Table 6. Expert Review Validation Results

Aspects assessed		Assessment Indicator	Validators			Value
			1	2	3	
	1.	The questions are in accordance with the indicators, namely multiple choices.	5	5	4	4.67
	2.	The questions are in accordance with the latest content and material for nuclear physic introduction.	5	5	5	5.00
Material	3.	The material is in accordance with the learning competency or achievement.	4	5	5	4.67
suitability	4.	Homogeneous and logical answer choices.	4	4	5	4.33
	5.	There is only one answer key (no bonus).	5	5	5	5.00
	6.	Questions are written clearly and firmly.	4	5	5	4.67
	7.	The length of the answer choices is relatively the same.	4	5	5	4.67
	8.	Answer choices in the form of numbers or time are written sequentially from the smallest to the largest and vice versa.	4	5	5	4.67
Construction	9.	The answer choices do not use the statement that all answers are right or wrong.	5	5	5	5.00
	10.	The questions or answers do not depend on the previous questions or answers.	5	5	5	5.00
	11.	Using language that is in accordance with Indonesian language.	5	4	5	4.67
	12.	Using communicative language.	4	5	5	4.67
Language	13.	Do not use local or taboo language.	5	5	5	5.00
	14.	Appearance of the application used is attractive.	4	4	4	4.00
	15.	The application used is easy to access and used for evaluation.	5	5	5	5.00
Application	16.	The application already uses an adequate security system.	5	4	5	4.67
	17.	The application used does not need to be downloaded on a cellphone or laptop (Practical and Economical).	4	5	5	4.67

Table 7. Conclusionand Validationof Expert Review Results

Validation Aspect	average	Validity Level
Material suitability	4.73	Very valid
Construction	4.80	Very valid
Language	4.78	Very valid
Application	4.58	Valid

Based on the suggestions and comments from the expert review and the results in table 7, it can be shown that the instrument developed is very valid and produces prototype 2. The next step is to test at the one-to-one evaluation, small group evaluation, and wide trial stages.

One-to-One Evaluation Results

Prototype.2 trial aims is to determine the level of practicality of the product. The researcher conducted a pilot test with 3 students who had low, medium and high ability levels. The results of student responses are in tables 8 and 9.

Based on the comments of the student there were no revisions needed, because the students as users were very satisfied. The next step is to test it on a small group evaluation.

Table 8. Results of Student Assessment Stage One to One

Student Code	Average Response	Practicality Level
MA	3.86	Very Practical
RG	3.71	Very Practical
RF	3.86	Very Practical
Average	3.81	Very Practical

Table 9. Student Comments and Suggestions at the One to One Evaluation Stage

Student Code	Comments and suggestions
MA	The application is very easy to access with an attractive appearance
RG	In my opinion, it is good and suitable to be applied as an evaluation tool
RF	Very practical, attractive, coupled with a level of security in the form of a class code and a registered user name.

Small Group Evaluation

The results of the one-to-one trial were continued in this trials with more users (10 FKIP UNSRI physics education students) with different abilities. After completing the questionnaire, students were asked to provide comments and suggestions through a questionnaire. The following are the results of student responses in table 10.

Table 10. The Average Results of Student Responses

Student Code	Average	Practicality Level
AD	4	Very Practical
AA	4	Very Practical
AO	4	Very Practical
AR	4	Very Practical
BY	4	Very Practical
FN	3.86	Very Practical
GI	3.57	Very Practical
IN	4	Very Practical
IM	4	Very Practical
MA	3.57	Very Practical
Average	3.89	Very Practical

Detailed student comments and suggestions are presented in table 11.

Table 11. Student Comments and Suggestions on the Small Group Evaluation

Student Code	Comments and suggestions
AD	The instruments are good and completed (it can add pictures, formulas and tables). The application also easy to access
AA	You can add an image with submit image option to the existing answer box, so that it can make it easier to enter answers with lots of formulas and symbols.
AO	The instruments are good, questions and answers are easy to understand. All points are in the right groove. The ease in displaying the test evaluations is also good.
AR	The questions are in accordance with the learning achievement indicators and the applications are also very practical
BY	The questions are easy to work on via a Smartphone or computer and are very practical in the future to be able to provide even more calculation questions
FN	It's good, very suitable as the latest evaluation tools for students.
GI	In my opinion, the questions given are easy to understand and are also very close to the nuclear physics introduction material that has been studied
IN	The questions are quite complete and meet the learning achievement indicators and are ready to be used as a practical computer-based evaluation tool
IM	The assessment instruments are good. The questions that are clear and easy to understand. For computer-based evaluation tool it is very practical, and the appearance is also attractive so it is easy to understand.
MA	It's better to create an add image feature to make it easier to send answers that have to write symbols that cannot be done through the website

Based on the student comments and suggestions in table 11. We have revised and added a number of things to make it easier to send answers. So that we progress to the next step, performing wide trials for students taking introductory physics courses in the even semester of the 2022/2023 academic year. We run the test to 36 of students with an average score of 3.72 in the very practical category. The results of this wide trials will be the final product of this development. Instrument quality is also determined by its reliability and the results are in the following table.

Table 12. Reliability Statistics for the Midterm

Cronbach's Alpha	No Items
.819	25

Table 13. Reliability Statistics for Final Semester Examination

Cronbach's Alpha	No Items
.851	35

From the results shown in table 12 and table 13, we can see the reliability of the midterm and final semester exams, Cronbach's alpha for those exams were 0.82 and 0.85, respectively, its mean that they are in the reliable category. At this stage, the results of the development become the final product that can be used as a computer-based assessment instrument for nuclear physics introduction courses.

Discussion

In the needs analysis stage, it was found thatthe material for the nuclear physics introduction courseis 15 sub-materials given in a semester, as supporting lecturers wanted to measure the achievement of lectureindicators for each concept being taught so that there was a need for instruments that were valid, practical and easy to use. In addition, students were also asked for their responses regarding the development of computer-based assessment instruments by distributing questionnaires to them. The descriptions are: Outof 64 students, only 51 students filled out and returned the questionnaire; 84.3% of students took the Introductory Physics course. Strongly supports the existence of computer-based assessment instruments; 94.1% of students want a computer-based assessment system compared to writtena ssessments. The results of the documentation of thelecturers are that there are many questions that have been tested on students from 2012 until now, both in the form of essay questions or objective questions taken from various handbooks. Thisis in accordance to thed evelopment research step, namely Analysis (Nature of analysis activities) accordingtoVisscher-Voerman (1999).

In the Design (The Shapingof Solution) stage, Visscher-Voerman (1999) found a solution to the needs by starting them from: (1) examining the material provided during the lecture which consisted of 15 sub-materials and seeing the learning achievements with different levels of difficulty,that are designed according to the semester lecture plan, (2) determines and arranges the instrumentgrid, to suit the material being studied, (3) determines the number of test items and scoring guidelines. Then the last stage, is the evaluation stage. The evaluation phase is divided into 5 steps, they are selfevaluation, expertreview, one to one evaluation, and small group evaluation and wide trials.

This research has produced a product in the form of a computer-based assessment instrument on the nuclear physics introduction material that have met the validity, practicality and reliability criteria. The validity of the instrument was obtained from review by three lecturer reviewers in the content, construction, language, and application sections. The developed instrument can be used as an assessment tool because it meets the validity criteria, an instrument can be used as an assessment tool after it met the validity and reliability criteria (Mardapi, 2012; Sumintono, 2016). The reliability tested with the help of SPSS version 22.0, so it can be carried out simultaneously on all items. The decision making according to Sujarweni (2014) is, if the Cronbach's alpha value > 0.6 the instrument is declared reliable or consistent and if the Cronbach's alpha value < 0.6 the instrument is declared unreliable or inconsistent. Based on the value of the reliability score obtained, it means that the questions that have been developed are reliable. This means that the tests developed can give the same results when given to the same group even though they are carried out by different people, at different times or occasions and in different places (Arikunto, 2012).

The advantages of the product in this study are: There is a class code for security so that it safe from intruders or unknown people entering and accessing the questions; The application used is easy to access on both laptops and smartphones; The appearance is more attractive as a research evaluation tools (Hamidah & Wulandari, 2021), (4) It can add images, graphs, tables and formulas and; Questions can be randomized and can be given a time limit. As for the shortcomings of the product in this study, namely random questions cannot be given a number.

Conclusion

This research produced a product in the form of a computer-based instrument assessment of nuclear physics introduction material using a valid, reliable and

practical form facade application. The validity of the instrument was obtained from three lecturer reviewers on the content, construct, and language and application sections. With respective values of 4.73 (very valid), 4.80 (very valid), 4.78 (very valid) and 4.58 (valid). Instrument reliability was determined from Cronbach's alpha value of 0.82 for 25 midterm exam items and 0.85 for 35 last semester exam items respectively. The practicality of the instrument is known from the results of one to one, small group, and wide group trials with respective values of 3.81, 3.89, and 3.72 in the very practical category.

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Conflicts of Interest
This research focuses on the assessment of Introductions Nuclear Physics lectures.

References

Anderson, L. W. (2003). *Clasroom Assessment: enhancing the quality of teacher decision making*. Lawrence Erlbaum Associates, Inc.

Arikunto, S. (2012). *Dasar-dasar Evaluasi Pendidikan*. Bumi Aksara.

Astuti, D., Kurniasari, D., Rusilowati, A., Subekti, N., & Artikel, I. (2014). Pengembangan Buku Suplemen Ipa Terpadu Dengan Tema Pendengaran Kelas Viii. *Unnes Science Education Journal*, *3*(2), 462–467. Retrieved from http://journal.unnes.ac.id/sju/index.php/usej

Daryanes, F., & Ririen, D. (2020). Efektivitas Penggunaan Aplikasi Kahoot Sebagai Alat Evaluasi pada Mahasiswa. *Journal of Natural Science and Integration*, *3*(2), 172. https://doi.org/10.24014/jnsi.v3i2.9283

Giancoli. (2001). *Fisika Jilid 1*. Erlangga.

Hamidah, M. H., & Wulandari, S. S. (2021). Pengembangan Instrumen Penilaian Berbasis HOTS Menggunakan Aplikasi "QUIZIZZ." *Efisiensi: Kajian Ilmu Administrasi*, *18*(1), 105–124. https://doi.org/10.21831/efisiensi.v18i1.36997

Hidayat, A. A. (2021). *Menyusun Instrumen Penelitian & Uji Validitas-Reliabilitas*. Health Books Publishing.

Imania, K. A., & Bariah, S. K. (2019). Rancangan Pengembangan Instrumen Penilaian Pembelajaran Berbasis Daring. *Jurnal Petik*, *5*(1), 31–47. https://doi.org/10.31980/jpetik.v5i1.445

Kusairi, S. (2013). Analisis Asesmen Formatif Fisika Sma Berbantuan Komputer. *Jurnal Penelitian Dan Evaluasi Pendidikan*, *16*, 68–87. https://doi.org/10.21831/pep.v16i0.1106

Mardapi, D. (2012). *Pengukuran Penilaian & Evaluasi Pendidikan*. Nuha Medika.

Murniati, M., Fathurrohman, A., & Letari, Y. (2022). Development of STEM-Based Digital Handouts for Nuclear Physics Introduction Courses During the Covid-19 Pandemic. *Jurnal Penelitian Pendidikan IPA*, *8*(2), 627–632. https://doi.org/10.29303/jppipa.v8i2.1389

Muslim, Z. M. (1994). *Pengantar Fisika Inti*. Fakultas Matematika dan Ilmu Pengetahuan Alam Uniersitas Gadjah Mada.

Nazhifah, N., Wiyono, K., & Pasaribu, A. (2021). *Pengembangan Instrumen Soal Tipe Pisa Berbasis Computer Untuk Mengukur Kemampuan Literasi Sains Peserta Didik Sekolah Menengah Pertama*. Universitas Sriwijaya.

Niniati, N., Sukariasih, L., & Sahara, L. (2020). Penerapan Model Inkuiri Terbimbing untuk Meningkatkan Keterampilan Proses Sains dan Hasil Belajar Siswa SMPN. *Jurnal Penelitian Pendidikan Fisika*, *4*(2), 60. https://doi.org/10.36709/jipfi.v4i2.14186

Özden, M. Y., Erturk, I., & Sanli, R. (2004). Students' perception of online assessment: A case study. *Journal of Distance Education*, *19*, 77–93. Retrieved from https://www.ijede.ca/index.php/jde/article/view/100

Propham, W. J. (1995). *Classroom Assessment: What Teachers Need to Know*. Pearson.

Qodariah, S., Ilmi, M. A. N., Saputra, A. Y., & Pertiwi, R. A. (2019). Gratitude and Organizational Commitments in the Office Boy. *Proceedings of the Social and Humaniora Research Symposium (SoRes 2018)*. https://doi.org/10.2991/sores-18.2019.70

Riandry, M. A., Ismet, I., & Akhsan, H. (2017). Developing Statistical Physics Course Handout on Distribution Function Materials Based on Science, Technology, Engineering, and Mathematics. *Journal of Physics: Conference Series*, *895*, 012047. https://doi.org/10.1088/1742-6596/895/1/012047

Santoso, A. (2010). Pengembangan Computerized Adaptive Testing untuk Mengukur Hasil Belajar Mahasiswa Universitas Terbuka. *Jurnal Penelitian Dan Evaluasi Pendidikan*, *14*(1). https://doi.org/10.21831/pep.v14i1.1976

Saputro, B. (2017). *Manajemen penelitian pengembangan (research & development) bagi penyusun tesis dan disertasi*. Aswaja Presindo.

Sujarweni, W. (2014). *SPSS Untuk Penelitian*. Pustaka Baru Press.

Sumintono, B. (2016). Aplikasi Pemodelan Rasch pada asesmen pendidikan: Implementasi penilaian formatif (assessment for learning). *Makalah Dipresentasikan Dalam Kuliah Umum Pada Jurusan Statistika, Institut Teknologi Sepuluh November, Surabaya*, *March*, 1–19. Retrieved from https://eprints.um.edu.my/15876/1/ITS_rasch_model_asesment_for_learning.pdf

Suyoso, S., Istiyono, E., & Subroto, S. (2017). Pengembangan Instrumen Asesmen Pengetahuan Fisika Berbasis Komputer Untuk Meningkatkan Kesiapan Peserta Didik Dalam Menghadapi Ujian Nasional Berbasis Komputer. *Jurnal Pendidikan Matematika Dan Sains*, *5*(1). https://doi.org/10.21831/jpms.v5i1.12461

Van Den Akker, J. (1999). Principles and methods of development research. In J. Van Den Akker, N. Nieveen, R. M. Branch, K. L. Gustafson, & T. Plomp (Eds.), *Design Methodology and Developmental Research in Education and Training* (pp. 1–14). Kluwer Academic Publishers.

Visscher-Voerman, I. (1999). Educational Design and Development: A Study of Dutch Design Practices. In J. Van Den Akker, N. Nieveen, R. M. Branch, K. L. Gustafson, & T. Plomp (Eds.), *Design Methodology and Developmental Research in Education and Training* (pp. 45–58). Kluwer Academic Publishers.

Zahara, N. (2015). Evaluasi Pembelajaran Online Berbasis WEB sebagai Alat Ukur Hasil Belajar Siswa pada Materi Dunia Tumbuhan Kelas X MAN Model Banda Aceh. *Seminar Nasional Biotik*, *2*(1). Retrieved from https://jurnal.ar-raniry.ac.id/index.php/PBiotik/article/view/2731/1988