THE DEVELOPMENT OF FOUR-TIER DIAGNOSTIC TEST INSTRUMENT TO IDENTIFY THE LEARNERS' MISCONCEPTION ON CIRCULAR MOTIONS

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ABSTRACT

Teachers must be aware of the learners' difficulties while understanding a concept. They should also improve the learners so the learners could master the concepts excellently. The misconception diagnostic test may become the alternative to reveal the misconception causes or factors. This research is a development study with a 4D development model. It aims to develop the diagnostic test instrument in the form of a four-tier test to identify the learners' misconceptions about circular motion. The developed test consisted of forty multiple-choice questions. The researchers involved five experts to validate the content. The result was the instrument's reliability obtained an average percentage of 86.34%. The empirical test results found 40 test items were valid with the excellent distinguishing category. The question reliability formula was using Kuder Richardson with a score of 0.785, categorized high. The developed test was in the form of multiple-choice to identify the learners' misconceptions. The test could be the assessment alternative to evaluate physics learning.

INTISARI

Guru perlu mengetahui kesulitan siswa dalam memahami suatu konsep dan melakukan perbaikan, sehingga siswa dapat menguasai konsep dengan baik. Tes diagnostik miskonsepsi dapat menjadi alternatif untuk mengungkap penyebab atau faktor miskonsepsi pada siswa. Penelitian ini merupakan studi pengembangan dengan menggunakan model pengembangan 4D dengan tujuan mengembangkan instrumen tes diagnostik dengan bentuk Tes Empat Tingkat (*four-tier test*) untuk mengidentifikasi miskonsepsi siswa pada materi Gerak Melingkar. Instrumen tes diagnostik *four-tier test* yang dikembangkan terdiri dari 40 pertanyaan pilihan ganda. Hasil validasi konten oleh lima ahli menyatakan bahwa instrumen ini sangat layak dengan persentase rata-rata 86,34%. Hasil uji coba empiris menunjukkan sebanyak 40 item tes diagnostik

memiliki kriteria valid, dengan tingkat kesulitan dan daya beda soal dalam kategori baik. Reliabilitas pertanyaan dianalisis menggunakan rumus Kuder Richardson sebesar 0,785 dan termasuk kategori tinggi. Instrumen *Four-tier test* yang dikembangkan dalam bentuk pilihan ganda ini dapat digunakan untuk mengidentifikasi miskonsepsi siswa dan juga dapat digunakan sebagai alternatif asesmen dalam melakukan evaluasi pada pembelajaran fisika.

I. Introduction

Teachers must be aware of the learners' learning problems so that teachers can take the appropriate solutions. One of the most frequently observed problems is a misconception. It usually deals with an incorrect explanation about a relevant physics concept that is agreed by scientists. This misconception is observable during the daily life experience while the learners are interacting with their environment [1]. This experience leads to an inner-theory establishment that may be incorrect. If the constructed intuition of learning is incorrect, it will be difficult to correct it because it consistently allows the incorrect concept to be the basis for the learner [2]. Therefore, physics learning should emphasize understanding rather than memory [3].

The physics learning process should not only present new ideas but change the previous ideas of the learners. Thus, they could receive an understanding of facts, concepts, principles, laws, and theories with scientific reasoning. At the new learning stage, learners have already had the background knowledge from their daily experience and obtained information from their surroundings [4]. The knowledge may change or remain still as the accepted learning process. Learning physics still has problems with misconceptions of the learners. Thus, it requires further identification to determine the learners' conceptual understanding levels. This matter requires further review and it is not merely a test of learning achievement. A test should be able to analyze the learners' misconceptions [5].

The observation results at Arrahmaniyah SHS, on 34 learners, proved 30 learners thought that the physics lesson was the most difficult lesson. This problem to understand physics concepts made them not interested in a physics lesson. The percentage of 88% of learners of the school was not interested in a physics lesson. They did not pay attention or even did not listen to the teacher's explanation while learning physics. They did not want to autonomously learn before the class began. They did not learn the given materials after the class. These matters made them did not understand the physics concepts and led to misconceptions. The observation results proved that the most difficult physics misconception was the circular motion concept. The previous studies showed similar findings. They found learners with circular motion misconception [6]–[8].

One of the ways to detect misconceptions is the diagnostic test [5]. It is a test to check the strength and the weakness of the learners while learning a concept. Thus, the result could be used as the basis to follow [9]. The diagnostic test implementation at the beginning and the ending of learning could facilitate teachers to ensure the weaknesses and the strength of the learners. It is also useful to detect misconceptions of the learned materials [4]. An excellent diagnostic test provides accurate descriptions of the learners' misconceptions based on the information of their incorrectness. The excellent diagnostic question items should not only inform whether the learners understand certain material parts. The items should be able to reveal how the learners think while answering the questions even the incorrect answers [4].

The multiple-choice diagnostic test has various forms, such as one-tier, two-tier, three-tier, and four-tier multiple-choice tests. The four-tier diagnostic test is the development of the three-tier diagnostic multiple-choice test [10], [11]. The development deals with the increased confidence level of the learners while selecting the answers or reasons. The first tier contains multiple-choice options with three decoys and one key answer to select. The second tier contains the confidence level of the learners while selecting the answers. The third tier covers the reasons for answering the questions. The test has three reason selections and one opened-reason selection. The four-tier is the confidence level or degree for the learners to select the reason. This four-tier diagnostic test was differently developed within the intervals of one to six based on the study of [12].

The developed test would be useful for the teachers to (1) identify the confidence level of the answers and the selected reasons of the learners. Therefore, teachers could elicit more conceptual understanding strength from the learners; (2) diagnose the learners' misconceptions comprehensively; (3) determine the material parts that require more emphasis; (4) plan the better learning to avoid learners' misconceptions [9], [13].

The occurring misconceptions should be overcome because it hinders the learners to understand the concepts scientifically [14]. This research aims to develop the four-tier diagnostic test about the learners' misconceptions and to determine the reliability of the instrument to identify the learners' circular motion misconceptions. It also aims to test the developed test to identify the misconception.

II. Research Methodology

This research and development developed the four-tier diagnostic test to find out learners' misconceptions on circular motion. The R&D model was 4D with stages from defining, designing, developing, and disseminating. This research limited the instrument development only at the developing stage exactly in the limited-scale product test. The applied instruments were observation sheets, the four-tier test diagnostic instrument sheet, and the four-tier test validation sheet.

The applied data analysis stages were analyzing the validity, reliability, difficulty, distinguishing power, questionnaire analysis, learners' misconception analysis, and the four-tier diagnostic test result interpretation. The validity test involved two expert lecturers. The reliability test used the KR-20 formula. The learners' misconception analysis used Caleon & Subramanian's equation [12].

$$CDQ = \frac{(CFC-CFW)}{S} \tag{1}$$

The equation tells that CFC is the average of learners' confidence levels that answer correctly. CFW refers to the confidence average score level of learners that incorrectly answer. Then, S is the standard of deviation of the confidence level. The result interpretation grouped the learners into learners with clear, unclear, and misconception understanding. The high confidence level was when learners selected the scale-4 option (confident), scale-5 option (strongly confident), or scale-6 option (extremely confident). The low confidence level was when learners selected the scale-1 option (guessing), scale-2 option (feeling very not sure), or scale-3 option (feeling not sure).

III. Results and Discussion

The Defining Stage

The developed test was to overcome the encountered difficulties while having interviews or tests [15], [16]. Based on observation and the data collection, the researchers developed the diagnostic test instrument to identify the learners' misconceptions. The developed test was a four-tier test misconception diagnostic test. The defining stage required the researchers to identify the developed instrument and paid attention to some characteristics. They were 1) the investigated lesson, physics for X grade; 2) the developed test form, the four-tier test; 3) the tested question items, 40 question items; and 4) the applied materials in the test development about circular motion.

The Designing Stage

The researchers developed the instrument by (1) determining the materials, (2) creating diagnostic test question rubrics, and (3) writing the questions in the four-tier-test form, starting from the questions, answer option, the confidence level of the answers, reason, and confidence level of the reasons.

The four-tier test instrument framework is shown in Table 1.

Table 1. The four-tier test instrument framework

The developed *four-tier test* instrument framework	

1. Questions
   A. Option
   B. Option
   C. Option
   D. Option
	3. Reasons toward the selected
	   answers
	    A. Option
	    B. Option
	    C. Option
	    D. Option

2. The confidence level of the
   selected answer
   A. Confident
   B. Not confident
	4. The confidence level of the
	   selected answer
	    A. Confident
	    B. Not confident

The Developing Stage

The developed instrument consists of four-tier. They were questions, answers, confidence levels of the answers, reasons, and confidence levesl of the reasons. The developed questions were 40 items under the circular motion sub-topic. The instrument had to be validated by the experts before being used. The experts validated forty question items. The validating stage aimed to determine the validity of the developed question items before being used.

A test with high validity could reveal valid learning outcomes. Therefore, the experts of assessment and circular motion were very important for the validation stage [17]. Astutik (2018) [5] involved experts to validate the developed diagnostic test. Five experts validated the developed question items based on three assessment aspects: material, construct, and language aspects. The arrangement of the instrument assessment component was based on the validation sheet rubric. Each question item is given Y and T options. The Y option revealed when the question items were relevant to the indicators and obtained a score of 1. On the other hand, the T option showed when there was no relevance with the indicators and obtained a score of 0. The assessment result of each question item on each indicator was added. Then, the validity would be determined. After being validated, the researchers screened the questions based on the validation categories. For questions with excellent categories, they did not need further revisions and could be used. The experts' judgments are shown in Table 2.

Table 2. The experts' judgment

Experts	The content aspect (%)	The construction aspect (%)	The language aspect (%)	Average (%)
A	90	85	90	88,33
B	90	82	87	86,33
C	88	84	85	85,67
D	90	80	87	85,67
E	87	82	88	85,67
Criteria	Very reliable	Reliable	Reliable	Very reliable

Table 2 shows the final results of the test instrument validation. The average of three aspects was "very reliable". Thus, the instrument could be used.

The trial test involved thirty individuals of the X Science learning group. The learners worked on the test then the results were analyzed. The trial results were analyzed to find out the empirical validity of the developed question items. From the analysis results, forty questions had high until very high validity levels. The question items also had the average distinguishing power and the difficulty levels were normally distributed, from the easy until difficult levels. The researchers used the Kuler Richardson formula to analyze the question item reliability. The result was 0.785, categorized high. The confidence level increase of each answer and reason could measure the cognitive level difference of the learners. It would ease the detection of misconceptions. [18] found that it was difficult to differentiate the learners that did not know the concepts and those who had misconceptions. The four-tier diagnostic test could determine the learners' strength in mastering the concept via self-confidence levels while answering [19], [20].

The development stage had the purpose to improve the quality of this four-tier test by considering the answer possibilities that learners could easily guess. It was by creating the assessment indicators in the form of answer combinations to categorize. Second, it was describing the four-tier test questions to be more comprehensive and varied so that learners would obtain new insight. Third, providing an answer sheet so that learners could provide answers that were not only provided. This research provided the question examples to explain how the test could coordinate the learners to guess. The process to reveal the learners' misconceptions required a specific four-tier diagnostic test than the typical multiple-choice. Multiple choice had limitations because it could not differ the correct answers due to the correct reasons and correct answers with incorrect reasons [12], [15], [21].

IV. Conclusion

This research concluded that the developed test could measure the learners' misconceptions. The instrument was also reliable and valid to use based on the empirical findings. The developed test had high validity results. It also had excellent distinguishing power and proportional difficulties. The question reliability obtained

a score of 0.785, categorized high. From the explanation, the four-tier test was suitable to identify the learners' misconceptions on circular motion. Besides that, the four-tier test could be an alternative to conduct a physics learning evaluation.

Bibliography

[1]   D. Pebriyanti, H. Sahidu, and S. Sutrio, "Efektifitas Model Pembelajaran Perubahan Konseptual Untuk Mengatasi Miskonsepsi Fisika pada Siswa Kelas X Sman 1 Praya Barat Tahun Pelajaran 2012/2013," *J. Pendidik. Fis. dan Teknol.*, vol. 1, no. 2, pp. 92–96, 2017.

[2]   Q. Fariyani and A. Rusilowati, "Pengembangan Four-Tier Diagnostic Test Untuk Mengungkap Miskonsepsi Fisika Siswa Sma Kelas X," *J. Innov. Sci. Educ.*, vol. 4, no. 2, 2015.

[3]   F. Rohim and H. Susanto, "Penerapan model discovery terbimbing pada pembelajaran fisika untuk meningkatkan kemampuan berpikir kreatif," *UPEJ Unnes Phys. Educ. J.*, vol. 1, no. 1, 2012.

[4]   F. N. Sholihat, A. Samsudin, and M. G. Nugraha, "Identifikasi miskonsepsi dan penyebab miskonsepsi siswa menggunakan four-tier diagnostic test pada sub-materi fluida dinamik: azas kontinuitas," *J. Penelit. Pengemb. Pendidik. Fis.*, vol. 3, no. 2, pp. 175–180, 2017.

[5]   R. Annisa, B. Astuti, and B. N. Mindyarto, "Tes diagnostik four tier untuk identifikasi pemahaman dan miskonsepsi siswa pada materi gerak melingkar beraturan," *J. Pendidik. Fis. dan Keilmuan*, vol. 5, no. 1, pp. 25–32, 2019.

[6]   F. S. Tarisalia, I. D. A. Irawan, and T. N. Fis, "Studi Pustaka Miskonsepsi Siswa dalam Konsep Gerak Lurus, Gerak Parabola, dan Gerak Melingkar," *J. Kependidikan Betara*, vol. 1, no. 4, pp. 208–217, 2020.

[7]   D. Yolenta and L. Sutrisno, "Deskripsi Miskonsepsi Siswa SMA Sekecamatan Kapuas Tentang Gerak Melingkar Beraturan Menggunakan Three-Tier Test," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 4, no. 3, 2014.

[8]   J. Firmansyah, "Penerapan model pembelajaran generatif untuk mengurangi miskonsepsi pada materi gerak melingkar," *J. Serambi Akad.*, vol. 4, no. 1, 2016.

[9]   A. Rusilowati, "Pengembangan tes diagnostik sebagai alat evaluasi kesulitan belajar fisika," 2015.

[10]   A. S. Zaleha and M. G. Nugraha, "Pengembangan instrumen tes diagnostik VCCI bentuk four-tier test pada konsep getaran," *J. Pendidik. Fis. dan Keilmuan*, vol. 3, no. 1, pp. 36–42, 2017.

[11]   A. Zulfikar, A. Samsudin, and D. Saepuzaman, "Pengembangan Terbatas Tes Diagnostik Force Concept Inventory Berformat Four-Tier Test," *J. Wahana Pendidik. Fis.*, vol. 2, no. 1, pp. 43–49, 2017.

[12]   I. S. Caleon and R. Subramaniam, "Do students know what they know and what they don't know? Using a four-tier diagnostic test to assess the nature of students' alternative conceptions," *Res. Sci. Educ.*, vol. 40, no. 3, pp. 313–337, 2010.

[13]   D. S. Jubaedah, I. Kaniawati, I. Suyana, A. Samsudin, and E. Suhendi, "Pengembangan tes diagnostik berformat four-tier untuk mengidentifikasi miskonsepsi siswa pada topik usaha dan energi," in *Prosiding Seminar*

Nasional Fisika (E-Journal), 2017, vol. 6, pp. SNF2017-RND.

[14]   A. Alfiani, "Analisis Profil Miskonsepsi dan Konsistensi Konsepsi Siswa SMA pada Topik Suhu dan Kalor," in *PROSIDING SEMINAR NASIONAL FISIKA (E-JOURNAL)*, 2015, vol. 4, pp. SNF2015-IV.

[15]   D. K. Gurel, A. Eryılmaz, and L. C. McDermott, "A review and comparison of diagnostic instruments to identify students' misconceptions in science," 2015.

[16]   Z. D. Kirbulut and O. Geban, "Using three-tier diagnostic test to assess students' misconceptions of states of matter," *Eurasia J. Math. Sci. Technol. Educ.*, vol. 10, no. 5, pp. 509–521, 2014.

[17]   Kunandar, *Guru Profesional Implementasi KTSP dan Sukses dalam Sertifikasi Guru*. Jakarta: PT Raga Grafindo Persada, 2007.

[18]   L. Leoni, M. Maison, and M. Muslim, "Pengembangan Instrumen Tes Four-Tier untuk Mengidentifikasi Miskonsepsi Siswa Pada Materi Operasi Bentuk Akar," *J. Cendekia J. Pendidik. Mat.*, vol. 4, no. 2, pp. 771–778, 2020.

[19]   D. A. Prabaningtias, H. T. M. Silitonga, and D. Mahmudah, "Pengembangan Tes Diagnostik Four Tier Menggunakan Aplikasi Google Form Pada Materi Fluida Statis SMA Pontianak," *J. Pendidik. dan Pembelajaran Khatulistiwa*, vol. 7, no. 10, 2018.

[20]   W. B. Sheftyawan, T. Prihandono, and A. D. Lesmono, "Identifikasi miskonsepsi siswa menggunakan four-tier diagnostic test pada materi optik geometri," *J. Pembelajaran Fis.*, vol. 7, no. 2, pp. 147–153, 2018.

[21]   R. Diani, J. Alfin, Y. M. Anggraeni, M. Mustari, and D. Fujiani, "Four-tier diagnostic test with certainty of response index on the concepts of fluid," in *Journal of Physics: Conference Series*, 2019, vol. 1155, no. 1, p. 12078.