JPPIPA 9(5) (2023)

Jurnal Penelitian Pendidikan IPA

Journal of Research in Science Education

http://jppipa.unram.ac.id/index.php/jppipa/index

Development and Validation of Physics Learning Motivation Survey (PLMS) using Rasch Analysis

Judyanto Sirait[1*]

[1] Program Studi Pendidikan Fisika, Universitas Tanjungpura, Pontianak, Indonesia

Received: March 25, 2023
Revised: April 27, 2023
Accepted: May 12, 2023
Published: May 31, 2023

Corresponding Author:
Judyanto Sirait
judyanto.sirait@fkip.untan.ac.id

DOI: 10.29303/jppipa.v9i5.3481

Abstract: Motivation can affect the success of students' learning. Teachers need a valid instrument to measure students' motivation while learning physis. This study aims to describe the process of developing and validating of physics learning motivation survey (PLMS) for senior high school. Research and development approach is implemented in this study by following stages: define, design, develop, and disseminate. In the previous study, the survey has been generated 40 items with eight factors including teachers' factor, carrier plan, learning strategy, self-efficacy, instructional media, learning environment, learning interest, and online/offline instruction. The present study is to validate empirically the survey using Rach analysis by involving 947 senior high school students in Kalimantan Barat. The results from Rach analysis show that 35 items are acceptable which have infit and outfit mean square value from 0.5 to 1.5 logits. Then item reliability and person reliability are 0.99 and 0.91 respectively. This indicates that the PLMS is valid and reliable to measure students' motivation in learning physics.

Keywords: Motivation; Physics learning; Rasch analysis; Survey

Introduction

At the senior high school level or its equivalent up to the university level, the physics subject was first introduced. Physics is one of the fundamental and required subjects for the MIPA (mathematics and basic natural sciences), engineering, and health groups at the tertiary level. It is also a senior high school requirement or its equivalent for science majors. Numerous students believe that the subject of physics is very challenging, dense with mathematical formulas, and either not very relevant or only marginally relevant for future careers (Sirait et al., 2017). Many students are consequently less motivated to study physics and even avoid it by selecting other subjects like biology and chemistry (OECD, 2016).

The curriculum of education in Indonesia continues to experience changes including that of physics as a step to dealing with the rapid technological development. The "independent" curriculum that is currently being used covers two elements of the physics subject, namely understanding physics and process skills (Curriculum Standards and Education Assessment Agency, 2022). Understanding physics is the material that should be mastered by students in order to have basic knowledge and skills that could be applied in daily life. Then the abilities to observe, ask and predict, plan investigations, analyze data, and communicate the results are being the process skills. Meanwhile, the attitudinal component is referred to as "Pancasila's student's profiles," which include piety to God, global diversity, critical thinking, creativity, independence, and reciprocal cooperation (Satria et al., 2016).

The efforts to improve students' abilities in physics such as knowledge, thinking and skills have been carried out through a lot of research including how to increase the mastery of concepts on various approaches and methods (Scheid et al., 2019). Furthermore, many strategies are taught to assist students in problem solving skills (Burkholder et al., 2020; Docktor, et al., 2015; Hsu, et al., 2004; Kuo, et al., 2013). It has also been developed to use media as a tool to assist students in learning how to abstract physics ideas (Ceberio et al., 2016; Podolefsky et al., 2010). However, research on students' attitudes towards learning physics, especially the motivation to learn physics still needs to be

How to Cite:
Sirait, J. (2023). Development and Validation of Physics Learning Motivation Survey (PLMS) using Rasch Analysis. *Jurnal Penelitian Pendidikan IPA*, *9*(5), 4063–4069. https://doi.org/10.29303/jppipa.v9i5.3481

developed considering that the affective aspect is one of the factors that influence students' learning success (Zoechling et al., 2022).

Motivation is an internal state that initiates or focuses on goal orientation (Schunk & DiBenedetto, 2020). In other words, motivation is a person's internal encouragement to accomplish a task or goal. According to this theory, a student has the motivation to study physics for the reasons that the student has goals to be achieved including to gain knowledge of physics concepts and get good grades. However, students' motivation does not only come from within themselves but could also come from external or environmental factors.

Motivation can be divided into two types, namely extrinsic and intrinsic (Ryan & Deci, 2000). External motivation is generally in the form of rewards and praise for good work and achievement. In the context of student learning, extrinsic motivation on one hand can be an effort to get good grades on exams, encouragement from parents, aspirations to further studying in college, and goals to get a job while intrinsic motivation, on the other hand, is the desire from within students to learn certain material or topics such as the example of learning physics.

Research on students' motivation to learn science has been carried out by developing several questionnaires. Tuan, Chin, & Shieh (2005) developed a students' motivation toward science learning-SMTSL questionnaire to measure the motivation of junior high school (SMP) students to learn science. The motivational elements in the questionnaire are self-efficacy, active learning strategies, science learning values, goals performance, goals achievement, and stimulation of learning environment. Furthermore, a questionnaire to determine students' motivation in the learning process has been developed, namely students' adaptive learning engagement in science (SALES) (Velayutham et al., 2011). Junior and Senior high school students were involved in developing this questionnaire. The questionnaire consists of four dimensions of motivation namely: learning goal orientation, task values, self-efficacy, and self-regulation.

The science motivation questionnaire (SMQ) has been developed by Glynn, et al. (2011) and Glynn, Taasoobshirazi, & Brickman (2009) applying five components of motivation, namely: intrinsic motivation, self-determination, self-efficacy, career motivation, and grade motivation. The questionnaire is used to measure students' motivation to learn science. Abraham & Barker (2015) also developed a motivational questionnaire in physics for high school students known as the Physics Motivation Questionnaire (PMQ). This questionnaire consists of five aspects of motivation, namely: interest value, utility value, performance perceptions, sex-stereotyped attitudes, and engagement. The purpose of the questionnaire is to determine students' motivation to study physics for certain materials and to find out whether students will continue to take physics subjects in the following academic year.

Questionnaires on students' motivation to study, especially that of physics subject are still limited and still need to be developed considering that learning motivation can affect student learning outcomes (Schunk & DiBenedetto, 2020). The questionnaires that have been developed are still limited and the motivation elements still need to be developed including that of the teacher factor taking into account that the teacher's role is very important in the students' success in learning physics. Then, the media factors should also be included in the motivational aspect given the development of technology and its use in the physics' teaching learning. Besides that, the use of media such as computers and the internet has become a necessity during the Corona Virus (COVID-19) pandemic situation. Thus, we should know as to what extent the media aspect influences students' physics learning motivation.

Sirait & Oktavianty (2021) has developed a motivational questionnaire for learning physics. The results of this study indicate that the questionnaire is a valid, reliable and suitable tool in measuring motivation to learn physics. However, this research is still in the pilot study stage involving relatively few participants and there are several items that need to be revised. Therefore, a further research that aims to produce a valid questionnaire involving large-scale participants is needed and to use the Rasch model to analyze data by testing the fit of the items and testing the effectiveness of the target items on students. This questionnaire is expected to provide information to teachers in designing learning that can increase students' motivation to study physics.

Method

The developmental research (R&D) was applied to develop this physics learning motivation questionnaire consisting of 4D: define, design, develop, and disseminate (Thiagarajan, 1974). The first phase of the research has reached the "develop" stage involving 150 high school students. The second phase is a follow-up research, namely "disseminate" to test a motivational questionnaire for learning physics on a broad scale. A total of 947 high school (SMA) students (313 boys and 634 girls) from 7 districts and 2 cities in West Kalimantan were involved in this study. The sampling was purposive (Cohen et al., 2018) where one school represented each district and city. From previous research, the physics learning motivation questionnaire that has been produced consists of 40 statement items with eight factors (Sirait & Oktavianty, 2021). For more details about the factors, items, and examples of the questionnaire statements are presented in Table 1.

Table 1. Dimensions of the physics learning motivation questionnaire

Factor Item	Item	Example Statement
Teacher	10,18,19,20,21,22, 23,24,25	#23 I like studying physics because the teacher always corrects the assignments and tests and giving feedback
Career	32,33,34,35,3 6	#32 I study physics seriously so that I may study at the college I want
Learning strategy	6,7,8,11,12	#8 I studied physics concepts first then afterwards study the formulas related to the concept
Self-efficacy	37,38,39,40	#37 I am motivated/happy to learn physics because I'm sure I can understand the concept of physics well
Learning Media	28,30,31	#31 online media and social media help me looking for materials or materials to make it easier for me to learn physics
Learning environment	9,13,14,15,16 ,17	#15 I prefer to study physics in the physics laboratory compared to in the classroom
Interest in learning physics	1,2,3,4,5	#1 I like learning physics because I study events (phenomena) in daily life
Online/offline learning	26,27,29	#27 it's easier for me to understand physics concepts taught in class accompanied by experiments rather than through online

The schools were contacted beforehand to find out if they would agree to allow a survey of their specific students to be conducted. The students of the willing schools are then given a link to fill out the questionnaire. Then, they are given a package of motivational questionnaire regarding the study of physics which contains respondent information such as name or initials, school name, district of origin as well as a questionnaire containing statements. The questionnaire is given online via the Google form. One of the reasons is that it may avoid direct contact with students during the Covid-19 pandemic. In addition, the data gathering is faster and inexpensive as well as errors minimization in submitting student data answers. The students were given about 15 to 20 minutes to fill out the questionnaire.

The development and validation of this physics learning motivation questionnaire is made by way of applying the Rasch model (Planinic et al., 2019). The Rasch model is often used when developing new instruments (Balta et al., 2022; Kirschner et al., 2016; Matejak Cvenic et al., 2022). There are various reasons for employing Rasch analysis, including it can translate ordinal data into interval data, it can assist linear computations for persons and things, and a Wright map can be built to evaluate constructs. There are two aspects tested, namely the item fitness to the overall constructs and the effectiveness of the target item to students.

Result and Discussion

Before answering the questionnaire, there are a number of general questions that students must answer such as their selection of subjects to choose should a national assessment is held and of their plans after school graduation. The fact shows that as many as 67% of students chose biology, 20% of students chose physics, and 13% of students chose chemistry. The above reflects that physics is one of the subjects that is less liked by students (Žák & Kolář, 2023). The fact that so few students choose physics could be attributed to misconceptions about the subject, such as the fact that there are numerous formulas to learn and the subject matter is challenging, making students fear failing or receiving a poor grade. This is in line with the findings of Abraham & Barker (2020) that the number of students taking physics subjects continues to decrease. Then 73% of students chose to continue their studies at universities, polytechnics, academies, and others. This demonstrates that the majority of respondents intend to advance or increase their knowledge and experience before entering the workforce (Glynn et al., 2011).

Rasch analysis is used to assess the construct validity of the physics learning motivation questionnaire by testing the fitness of the items to the entire construct and testing the effectiveness of the target items on students. Table 2 presents the statistics derived from the Rasch analysis. The first column displays the amount of items in the physics learning motivation questionnaire, particularly as many as 40 items. The second column contains the total score that constitutes the sum of the responses for each item. Student responses to each statement are counted using Likert scale numbering from 1 (strongly disagree) to 5 (strongly agree). The total score is sorted from the smallest to the largest. The Rasch measure is made by logit units that provide information related to the level of agreement for each item (Zoechling et al., 2022). The value of the Rasch measure is between -1.32 - 1.76. From top to bottom shows the items that are the most difficult to agree with to the items the easiest to agree with. Then the model of standard errors explains the uncertainty in item measures. The model standard errors values are between 0.04 and 0.05.

Table 2: Rasch item measures and statistics PLMS

Item	Total score	Measure	Model SE	Infit MNSQ	Outfit MNSQ	Point Measure Correlation
33	2335	1.76	0.04	1.10	1.20	0.45
14	2445	1.62	0.04	1.31	1.57	0.40
4	2916	1.02	0.04	0.87	0.92	0.49
12	3042	0.86	0.04	0.68	0.69	0.57
35	3111	0.77	0.04	0.95	0.96	0.54
6	3120	0.76	0.04	0.86	0.87	0.54
3	3145	0.72	0.04	0.89	0.88	0.53
39	3209	0.63	0.04	0.72	0.72	0.60
7	3311	0.49	0.04	0.87	0.87	0.51
11	3315	0.49	0.04	1.47	1.50	0.28
38	3392	0.37	0.04	0.63	0.64	0.61
8	3444	0.30	0.04	0.82	0.82	0.53
37	3477	0.25	0.04	0.58	0.59	0.64
40	3533	0.16	0.04	0.77	0.76	0.59
20	3573	0.11	0.04	1.64	1.69	0.26
34	3573	0.11	0.04	0.91	0.89	0.56
2	3574	0.10	0.04	0.81	0.82	0.53
1	3607	0.05	0.04	0.66	0.65	0.57
16	3610	0.05	0.04	0.90	0.88	0.53
5	3628	0.02	0.04	0.81	0.81	0.54
15	3683	-0.07	0.04	1.46	1.48	0.33
32	3684	-0.07	0.04	0.81	0.79	0.59
28	3690	-0.08	0.04	1.22	1.29	0.41
13	3747	-0.18	0.04	1.53	1.54	0.35
29	3808	-0.28	0.04	1.24	1.28	0.37
36	3813	-0.29	0.04	0.83	0.81	0.58
23	3863	-0.38	0.04	0.81	0.84	0.49
19	3886	-0.42	0.04	0.81	0.81	0.51
21	3894	-0.44	0.04	0.79	0.81	0.53
17	3906	-0.46	0.04	1.18	1.17	0.40
24	3920	-0.49	0.04	0.87	0.87	0.46
22	4002	-0.65	0.05	0.95	0.90	0.49
30	4017	-0.68	0.05	1.27	1.28	0.36
9	4027	-0.70	0.05	1.46	1.46	0.30
26	4046	-0.74	0.05	1.63	1.58	0.35
31	4077	-0.81	0.05	1.17	1.23	0.37
27	4090	-0.83	0.05	1.45	1.43	0.37
25	4101	-0.86	0.05	0.83	0.81	0.50
18	4120	-0.90	0.05	0.91	0.88	0.46
10	4283	-1.32	0.05	1.19	1.16	0.36

Item 33 is the item with the lowest score, meaning that it is the most difficult for students to agree with the statement of "I study physics seriously because I want to be a physics teacher in the future". This statement is part of the career motivation dimension. When viewed from the percentage of students' choices, whereby around 50% of them chose strongly disagree and agree, 35% undecided, and only 15% agree and strongly agree. This indicates that only a few of the respondents chose a career to become a physics teacher. Most of the students easily agree to statement number 10, namely "I prefer to work on physics questions if the teacher has given an example of the solution or there is an example of the solution in the book". Item no. 10 is included in the teacher factor dimension where 92% of students agree and strongly agree with the statement. This shows that students are less enthusiastic if they have to solve problems that have no previous examples. In other words, students will be interested in following the steps that already exist.

Furthermore, the infit and outfit of MNSQ (mean square) explains how well the data fit the Rasch model. The MNSQ infit and outfit indexes for the 40 statement items are presented in Table 2. According to Wright & Linacre (1994), the acceptable value for survey data is between 0.5 and 1.5. This value is also used by Taasoobshirazi et al. (2015) when developing a physics metacognition questionnaire. Then Planinic et al. (2019) state that good instruments such as tests and questionnaires must have an MNSQ's infit and outfit value of that range. According to the Rasch model, the values outside the suggested ones indicate the existence of data divergence from what is expected. A value of less than 0.5 indicates that the response is very predictable and does not provide useful information while a value above 1.5 indicates misinformation. Based on these criteria, there are 4 items (13,14,20,26) that need to be excluded because they have an infit and outfit mean square value above 1.5. Items 13 and 14 are in the same dimension, namely the learning environment. Item 13, that reads "I like learning physics if students are divided into groups". This statement encourages students to study in groups while some students like to study individually. Then, item 14 reads, "I like studying physics because there is competition in class". This statement is also not good because studying physics does not mean one has to compete. Item 20 reads, "I like learning physics because the physics teacher gives a few assignments that fall into the teacher's factor dimension". This item is also contradictory because students who are highly motivated are happy with teachers who give few assignments. Then, item 26 regarding the choice of online or offline learning mode. Students have their own preferences and this provides an opportunity for students to choose one mode of learning. Based on the stated reasons, these four items cannot be included in this questionnaire.

Point measure correlation will test whether student responses to items correlate with the level of persons' approval (the higher a person measures, the higher the rating on the item) (Linacre, 2012). All correlations must be positive; seen from Table 2, the correlation value for all items is positive. In addition, the recommended point measure correlation value is above 0.3. Based on Table 2, the correlation values below 0.3 are on items 11 and 20; thus item 11 needs to be excluded and the low correlation value also strengthens that item 20, which was previously issued based on the MNSQ infit and outfit, not to be included in the value range.

Figure 1 presents a Wright map which illustrates the relationship between persons and items. Persons and items are in the same unit on the Wright map which can compare items with items, persons with persons, and persons with items (Planinic et al., 2019). The 40 things are arranged on the right side of the Wright map according to the degree of agreement, with the items that are hardest to agree on at the top and the easiest to agree on at the bottom. The distribution of 947 individuals, with those with strong motivation to study physics at the top of the map and those with low motivation at the bottom, can be seen on the left side of the Wright map. The interval scale of the logit value is depicted by the vertical line. Nine people are represented by each symbol of (#), while one to eight is represented by each symbol of (.). The "M", "S" and "T" symbols respectively stand for the mean, one and two standard mean deviations.

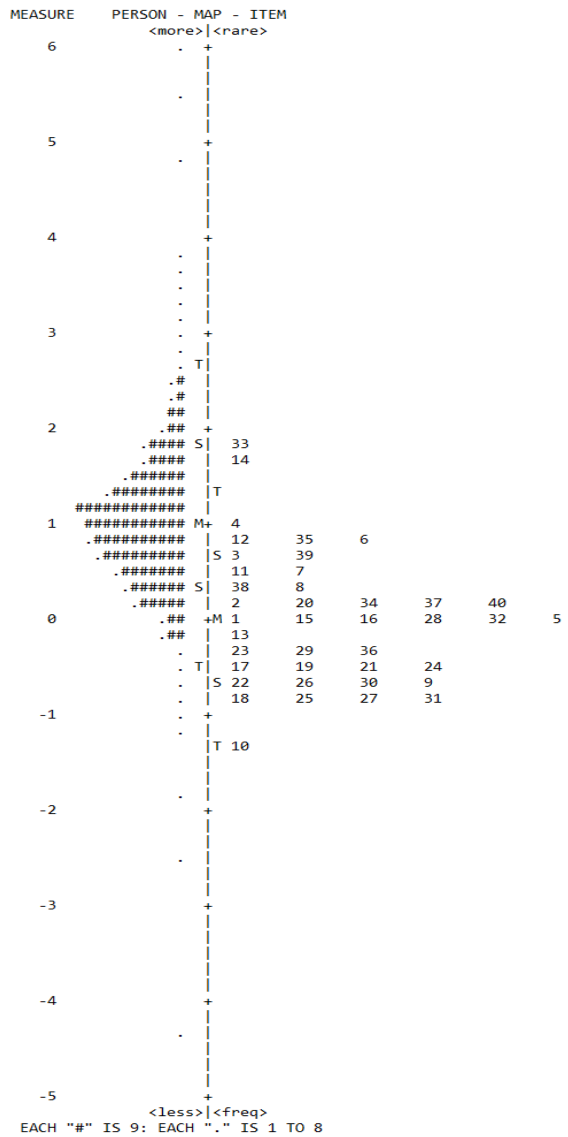

Figure 1. Wright Map of PLMS

There is no too wide a gap in the distribution of items. There are several groups of items that overlap, such as items 1,15,16,28,32,5 which indicate redundancy at the approval level of the items. However, this questionnaire consists of 40 items and they respectively measure different aspects of motivation to learn physics. The above mentioned six items do not measure the same aspect of motivation. Indications of this repetition also occur in the physics metacognition questionnaire (Taasoobshirazi et al., 2015), but because these items are in different dimensions and measure different aspects of metacognition, these items do not need to be discarded.

According to the statistical study, the questionnaire's item separation is 15.20, and its item reliability is 0.99. The sample in this study has a person separation of 3.16 and a person dependability of 0.91. This individual dependability number is equivalent to the questionnaire reliability index from earlier studies

(Sirait & Oktavianty, 2021). The Rasch analysis uses a 0.04 standard model for the item and a mean item measure of zero logits. The standard error model is 0.21 and the mean person measure is 1.05.

Conclusion

This study created a questionnaire with eight motivating elements to assess students' motivation to study physics. The 35 items that were deemed to be acceptable and reliable based on the Rasch analysis. Values for both person and item dependability were 0.91 and 0.99, respectively. Thus, teachers can utilize this questionnaire to ascertain students' motivation for enrolling in physics class as a resource for the advancement of learning.

Acknowledgments
This study was supported by DIPA Universitas Tanjungpura 2021. Thank you for students who participated in this study.

Author Contributions
The author conducted this study individually including writing the research proposal, collecting and analyzing data, writing and reviewing this article until published it.

Funding
This research was funded by DIPA Universitas Tanjungpura in 2021 (4759/UN22.6/PG/2021).

Conflicts of Interest
The authors declare no conflict of interest.

References

Abraham, J., & Barker, K. (2015). An Expectancy-Value Model for Sustained Enrolment Intentions of Senior Secondary Physics Students. *Research in Science Education*. 45:509–526. https://doi.org/10.1007/s11165-014-9434-x

Abraham, J., & Barker, K. (2020). Motivation and Engagement with Physics: a Comparative Study of Females in Single-Sex and Co-educational Classrooms. *Research in Science Education*. 50:2227–2242. https://doi.org/10.1007/s11165-018-9770-3

Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia. (2022). *Capaian Pembelajaran pada Pendidikan Anak Usia Dini, Jenjang Pendidikan Dasar, dan Jenjang Pendidikan Menengah Pada Kurikulum Merdeka.*

Balta, N., Japashov, N., Salibašić Glamočić, D., & Mešić, V. (2022). Development of the High School Wave Optics Test. *Journal of Turkish Science Education*. https://doi.org/10.36681/tused.2022.123

Ceberio, M., Almudí, J. M., & Franco, Á. (2016). Design and Application of Interactive Simulations in Problem-Solving in University-Level Physics Education. *Journal of Science Education and Technology*, *25*(4), 590–609. https://doi.org/10.1007/s10956-016-9615-7

Cohen, L., Manion, L., & MOrrison, K. 2018. *Research Methods in Education,* 8th edition, Routledge, Taylor & Francis Group, London.

Cvenic, K. M., Planinic, M., Susac, M., Ivanjek, L., Jelicic, K., & Hopf, M. (2022). Development and validation of the conceptual survey on the wave optics. *Physical Review Physics Education Research, 18*(1), 010103. https://doi.org/10.1103/PhysRevPhysEducRes.18.010103.

Docktor, J. L., Strand, N. E., Mestre, J. P., & Ross, B. H. (2015). Conceptual problem solving in high school physics. *Physical Review Special Topics - Physics Education Research*, *11*(2). https://doi.org/10.1103/PhysRevSTPER.11.020106.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching*, *46*(2), 127–146. https://doi.org/10.1002/tea.20267

Glynn, S. M., Brickman, P., Armstrong, N., & Taasoobshirazi, G. (2011). Science motivation questionnaire II: Validation with science majors and nonscience majors. *Journal of Research in Science Teaching*, *48*(10), 1159–1176. https://doi.org/10.1002/tea.20442

Hsu, L., Brewe, E., Foster, T. M., & Harper, K. A. (2004). Resource Letter RPS-1: Research in problem solving. *American Journal of Physics*, *72*(9), 1147–1156. https://doi.org/10.1119/1.1763175

Kirschner, S., Borowski, A., Fischer, H. E., Gess-Newsome, J., & von Aufschnaiter, C. (2016). Developing and evaluating a paper and pencil test to assess components of physics teachers' pedagogical content knowledge. *International Journal of Science Education, 38*(8): 1347-1372. https: //doi.org/10.1080/09500693.2016.1190479

Kuo, E., Hull, M. M., Gupta, A., & Elby, A. (2013). How students blend conceptual and formal mathematical reasoning in solving physics problems. *Science Education*, *97*(1), 32–57. https://doi.org/10.1002/sce.21043

Linacre, J. M. (2022). *A user's guide to WINSTEP, MINISTEP, Rasch model computer programs, Program Manual 5.3.3*. Retrieved from http://www.winstep.com/manuals.htm

Liu, X. (2010). *Using and developing measurement instruments in science education: a rasch modelling approach.* Information Age Publishing.

Luo, T., Wang, J., Liu, X., & Zhou, J. (2019). Development and application of a scale to measure students'

STEM continuing motivation. *International Journal of Science Education, 41*(14):1885-1904. https://doi.org/ 10.1080/09500693.2019.1647472

Neumann, I., Neumann, K., & Nehm, R. (2011). Evaluating Instrument Quality in Science Education: Rasch-based analyses of a Nature of Science test. *International Journal of Science Education, 33*(10): 1373-1405. https://doi.org/ 10.1080/09500693.2010.511297

OECD. (2016). *PISA 2015 results (volume I): excellence and equity in education*. PISA, OECD. https://doi.org/10.1787/9789264266490-en

Planinic, M., Boone, W. J., Susac, A., & Ivanjek, L. R. (2019). Rasch analysis in physics education research: Why measurement matters. *Physical Review Physics Education Research, 15*(2), 020111. https://doi.org/10.1103/PhysRevPhysEducRes.15.020111

Podolefsky, N. S., Perkins, K. K., & Adams, W. K. (2010). Factors promoting engaged exploration with computer simulations. *Physical Review Special Topics - Physics Education Research*, *6*(2). https://doi.org/10.1103/PhysRevSTPER.6.020117

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and Extrinsic Motivations: Classic Definitions and New Directions. *Contemporary Educational Psychology*, *25*(1), 54–67. https://doi.org/10.1006/ceps.1999.1020

Satria, R., Adiprima, P., Wulan, K. S., & Harjatanaya, T. Y. (2022). *Panduan pengembangan projek penguatan profil pelajar pancasila. Badan Standar, Kurikulum, dan Asesmen Pendidikan Kementerian Pendidikan, Kebudayaan, Riset, dan Teknologi Republik Indonesia.*

Scheid, J., Müller, A., Hettmannsperger, R., & Schnotz, W. (2019). Improving learners' representational coherence ability with experiment-related representational activity tasks. *Physical Review Physics Education Research*, *15*(1). https://doi.org/10.1103/physrevphyseducres.15.010142

Schunk, D. H., & DiBenedetto, M. K. (2020). Motivation and social cognitive theory. *Contemporary Educational Psychology*, *60*(December 2019), 101832. https://doi.org/10.1016/j.cedpsych.2019.101832

Sirait, J., Sutrisno, L., Balta, N., & Mason, A. (2017). The development of questionnaire to investigate students' attitudes and approaches in physics problem solving. *Jurnal Pendidikan Fisika Indonesia, 13*(2), 79-87. https://doi.org/10.15294/jpfi.v13i2.6592

Sirait, J., & Oktavianty, E. (2021). Pengembangan dan validasi angket motivasi belajar fisika (AMBF): studi pilot. *Jurnal Ilmiah Pendidikan Fisika, 5*(3), 305-316. https://doi.org/10.20527/jipf.v5i3.3829

Thiagarajan, S., Semmel, D. S., & Semmel. M. I. (1974). *Instructional development for training teachers of exceptional children: A sourcebook*. Leadership Training Institute/Special Education University of Minnesota.

Tuan, H. L., Chin, C. C., & Shieh, S. H. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education*, *27*(6), 639–654. https://doi.org/10.1080/0950069042000323737

Velayutham, S., Aldridge, J., & Fraser, B. (2011). Development and validation of an instrument to measure students' motivation and self-regulation in science learning. *International Journal of Science Education*, *33*(15), 2159–2179. https://doi.org/10.1080/09500693.2010.541529

Wright, B. D., & Linacre, J. M. (1994). Reasonable mean-square fit values. Rasch Measurement Transactions, 8:3. Retrieved from https://www.rasch.org/rmt/rmt83.htm

Žák, V., & Kolář, P. (2023). Physics curriculum in upper secondary schools: What leading physicists want. *Science Education*, 1–36. https://doi.org/10.1002/sce.21785

Zoechling, S., Hopf, M., Woithe, J., & Schmeling, S. (2022). Students' interest in particle physics: conceptualisation, instrument development, and evaluation using Rasch theory and analysis. *International Journal of Science Education 44*(15), 2353-2380. https://doi.org/10.1080/09500693.2022.2122897