An analysis of problem-solving strategy using magic card science media on free falling topic

H. Saputro[a,b,*], L. Yuliati[b], P. Parno[b], S. Sunaryono[b], P. Hariati Winingsih[c,d], and R. Sebastian[c,e]

[a]*Department of Teacher Professional Education,*
Universitas Sarjanawiyata Tamansiswa, Jl. Batikan UH-III/1043 Yogyakarta 55167,
e-mail: hansaputro@ustjogja.ac.id; handoyo.saputro.2103219@students.um.ac.id
[b]*Department of Physics, Faculty of Mathematics and Natural Sciences,*
Universitas Negeri Malang, Jl. Semarang 5 Malang, 65145,
[c]*Department of Physics Education, Universitas Sarjanawiyata Tamansiswa,*
Jl. Batikan UH III, Yogyakarta, Indonesia,
[d]*Department of Science Education, Concentration of Physics Education,*
Graduate School, Universitas Negeri Yogyakarta,
[e]*Department of Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Yogyakarta,*
Jl. Colombo No 1, Sleman Yogyakarta, 55281, Indonesia.

Received 16 January 2024; accepted 30 April 2024

This study looked at how well physics teacher candidates used magic card scientific media to solve problems when learning about free fall motion. This kind of study is known as a quasi-experiment. 26 students from the Physics Education study program who were enrolled in an experimental class and a control group using magic scientific material made up the sample. Methods for gathering data that make use of test and documentation methods. N-gain data analysis techniques. According to the study's findings, the experimental class's N-gain was 0.77 in the high category and the control class's N-gain was 0.37 in the medium group. The experimental class's N-Gain-Present of 77.30% indicates that learning magic science was effective, whereas the control class's N-Gain-Present of 37.36% indicates that it was ineffective.

Keywords: Problem-solving; magic card science; free fall motion.

DOI: https://doi.org/10.31349/RevMexFisE.22.010219

1. Introduction

Problem-solving has drawn the attention of education professionals in the past 10 years due to a number of research projects. Students' aptitude for problem-solving, particularly in real-world situations, is a good indicator of their success in learning physics [1,2]. Their thinking may become more adaptable as a result [3]. Media and group projects can assist students in learning problem-solving techniques [4], in addition to helping them comprehend the fundamentals of physics [5]. When it comes to the identification of misunderstandings and challenges in resolving physics problems pertaining to motion, mechanics is at the top [6-8]. This is shown in the material of straight motion found that students experience misconceptions and problem-solving difficulties in understanding ideas, as well as understanding graphs that show relationship between position, velocity, and acceleration [9].

Although the problem-solving in physics instruction has been shown by numerous international experts, this does not imply that of the challenging issues pertaining to students' problem-solving skills have been resolved. The use of instructional aids media in physics can enhance students' comprehension of concepts and problem-solving skills. For example, physicists and researchers can improve students' problem-solving learning on free-fall motion by utilizing Phyphox in physics experiments based on smartphone acoustic sensors [10,11]. The abstraction of hard-to-understand physics concepts can also be solved by the use of instructional aids media in learning activities, which also enhances students' attitudes toward science and the effectiveness of the learning process [12]. Teaching aids for physics can enhance students' conceptual knowledge of the subject [13], foster the growth of critical thinking abilities, improve academic achievement [14], enhance their enthusiasm for learning [15], and foster students' inventiveness and creativity [16].

Magic science media can influence children's experiences in developing their imaginations and shaping their behavior by showcasing educational magic toys (EMT) with augmented reality technology [17]. It is based on the Error Detection Scheme. From the perspective of science education, learning through inquiry-based magic science media is more effective and, in addition to being fun, can pique students' interests. Effective learning activities can be produced by investigating the scientific concepts and information underlying the magic feats [18]. There is an increase in science learning for deaf children using magical science to visualize in 3D [19]. Although magic science as a learning tool for problem-solving is still little researched, articles about it have gained significant attention in the Nature Review Neuroscience and cognitive science trends, and they have had a positive influence on popular science journals [20-23]. Magic science can

be a useful tool to examine the subject from a wider angle because it is evident that this fact sparks new scientific curiosity [24,25]. Anything that makes sense from a concept that has a scientific explanation is called magic science. For instance, through simple-to-do but challenging-to-explain magic scientific experiments and demonstrations [26]. The impact that the growth of magic science has on people's appreciation of magic is a significant question that has been brought up by the recent surge in scientific research on magic [27]. This paper will investigate how well physics teacher candidates use magic card scientific media to solve problems as instructional aids media related to free fall motion, namely by comparing two learning groups, namely the experimental class using magic card science media learning (MCSML) and the control class using conventional learning (CL).

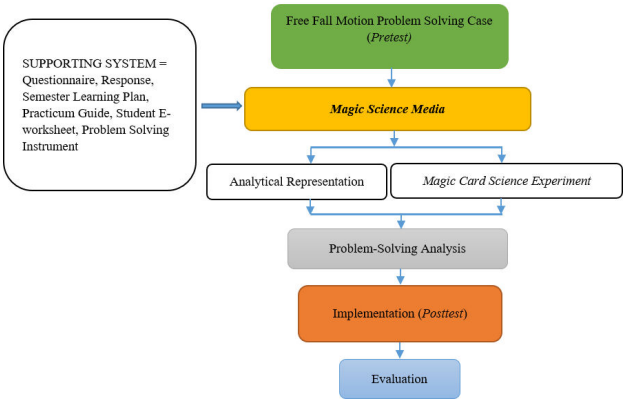

FIGURE 1. Learning design of magic card science media (MCSML).

TABLE I. Research design.

Class	Pre	Treatment	Post
Experiment (MCSML)	O1	X1	Q2
Control (CL)	O1	X2	Q2

Description: O1 = Pretest, Q2 = Posttest, X1 = Using MCSML, X2 = Using CL

TABLE II. Research activity steps.

Week	Research activity
1	Pretest class MCSML and CL
2	Treatment class MCSML and CL
3	Posttest class MCSML and CL

TABLE III. Category score N-Gain.

N-Gain	Category
$g < 0{,}3$	Low
$0{,}3 \leq g < 0,7$	Moderate
$g \geq 0{,}7$	High

TABLE IV. Category of effectiveness interpretation N-Gain.

Percentage(%)	Category
< 40	Not effective
40 - 55	Less effective
56 - 75	Quite effective
$\geq$76	Effective

2. Method

This type of research is quantitative research with a quasi-experimental design, which is an experimental design conducted without randomisation [28]. This kind of study compares two learning groups-the experimental class utilizing magic card science media learning (MCSML) and the control class using conventional learning (CL). The sample consisted of 26 Physics Education study programme students at one of Yogyakarta's Universities Accredited with Excellence and among the students won the National Level Competition and International Level Innovation. There were 26 aspiring physics teacher candidates in group A and 28 in group B. Three meetings were held to undertake learning on the subject of free fall motion (Table II). Figure 1, namely, by combining Analytical Representation and Magic Card Science (MCC) Experiments as media props in analysing free fall motion problem-solving.

Methods for gathering data via testing and documentation (pretest and posttest). Table I is used in the research design. The research activity steps are listed in Table II. Three essay questions that had been verified by physics specialists at Malang State University made up the pretest and posttest questions. The five signs that comprise the stages of issue solving are mathematical technique, logical development, useful description, physics approach, and specific application of physics [29].

The data analysis technique for issue-solving effectiveness using the normalized gain score (N-Gain) g [30] and converted to the N-Gain-Score and N-Gain-Present value categories [31] is shown in Table III and Table IV.

3. Findings and discussion

Tables III and IV present the findings of a problem-solving study on the subject of free fall motion that physics teacher candidates conducted utilizing magic card scientific media. Tables V and VI show that the two learning groups the MCSML class and the CL-class are homogeneous and normally distributed according to the results of the homogeneity test (Table VI) and the normality test (Table V).

3.1. T-test

Based on the trimmed mean of 0.06 in Table VI, it can be noted that the MCSML class and CL-class differ in their ca-

TABLE V. Results of data normality testing.

Class	KS			SW		
	Stat	df	Sig.	Stat	df	Sig.
Pretest MCSML	.206	26	.006	.920	26	.044
Posttest MCSML	.206	26	.006	.915	26	.034
Pretest CL	.180	28	.020	.895	28	.009
Posttest CL	.108	28	.200	.950	28	.199

Description: KS = Kolmogorov-Smirnov, SW = Shapiro-Wilk.

TABLE VI. Results of data homogeneity testing.

Based	Levene Statistic	df1	df2	Sig.
Mean	4.470	3	104	.005
Median	3.643	3	104	.015
Median with df	3.643	3	86,528	.016
Trimmed mean	4.340	3	104	.006

TABLE VII. Results of t-test analysis.

	Levene test		T-test						
	F	Sig.	t	df	Sig.(2tailed)	MD	Std.Err	95% Confid Interval	
								upper	lower
Equal variances assumed	11.306	.001	7.075	52	.000	16.052	2.269	11.499	20.605
Equal variances not assumed			7.226	41.729	.000	16.052	2.222	11.588	20.536

TABLE VIII. Average results of pretest and posttest scores of MCSML and CL classes.

Class	Pretest	Posttest	N-Gain Score	N-Gain-Persen (%)	Category.
MCSML	61.38	90.73	0.77	77.30	Effective
CL	60.29	74.68	0.37	37.36	Not effective

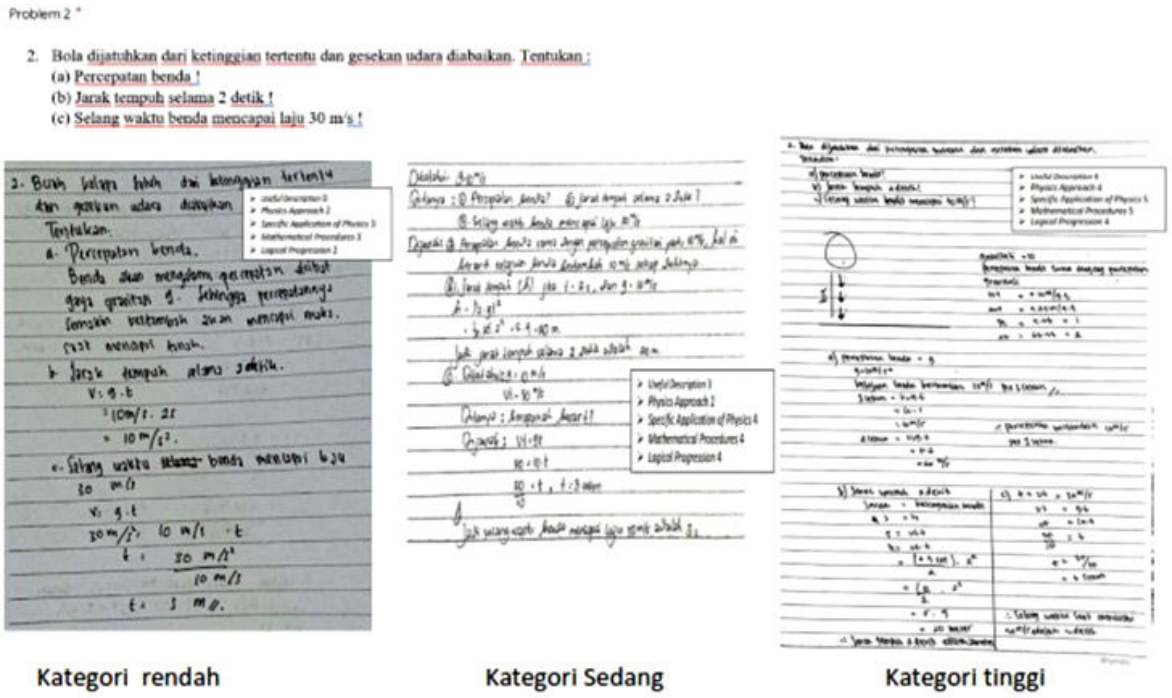

FIGURE 2. Results of the category of answers of physics teachers candidates on free fall motion material.

pacity to solve problems. This is corroborated by the average post-test score of 74.68 in the CL class and 90.73 in the MCMSL (Table VIII).

It is clear from Tables III and IV that the MCSML class outperformed the CL-class in the high-category assessment with a higher N-Gain score. Therefore, with a 39.36% in-

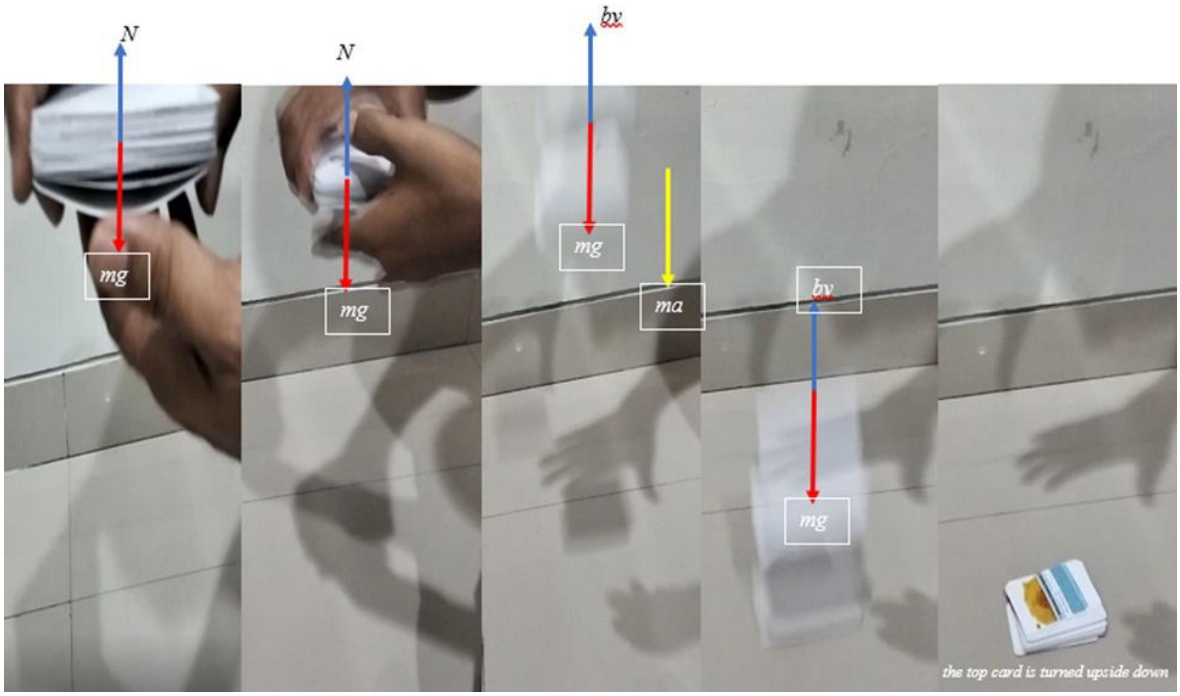

FIGURE 3. Magic card science experiment.

crease, it can be concluded that there is a difference in the efficacy of physics teacher candidates' problem-solving when learning about free fall motion utilizing MCSML and CL. Learning results are positively impacted by this outcome, of course. This result is consistent with research showing that the usage of magic science media in the classroom improves student learning results [32].

Candidates for constructive, active learning as physics teachers discover the benefits of learning through magic science media that are based on experiments and interactive experiences. Feedback, feelings, and confidence are supplied when a problem is solved to make problem-solving more effective [33]. Effective communication among group members is consistent with Piaget's theory that friendship will triumph over egoism [34,35]. Applicants for high-ability physics teaching positions might help lower-ability applicants by imparting knowledge and comprehension, which boosts social skills and self-confidence. Furthermore, the claim [36] that problem-solving and cooperative learning might foster the development of higher-order thinking abilities supports it. Through the steps of learning media magic science, students will engage in collaborative and participatory learning that includes Individual Preparation, Classroom Discussion, and Classroom Discovery. The curriculum will introduce appropriate and logical problem-solving techniques (based on evidence) on free fall motion material through communication and presentation. Friends discuss conclusions with one another. Class engagement and information exchange take place. Intergroup questions and answers help to aspire instructors hone their problem-solving abilities. This demonstrates that developing scientific character is a cognitive process with the ability to foster the growth of reason, particularly sophisticated reasoning for problem-solving [37]. First, as a problem-solving solution in magic scientific media employing analytical representation, and second, as a problem-solving finding from the pretest results of the average low category student's answer in conducting plug and chug Fig. 2.

The science experiment with the magic cards Fig. 3 illustrates how the top card appears upside down when it falls to the ground. This phenomenon may be scientifically described using the principles of physics, particularly the material of free fall motion [38,39], which is brought on by the presence of air resistance, which causes air friction. The reason the other cards remain unchanged (not inverted) is that just the acceleration caused by gravity is at work as there is no air resistance or other outside force.

4. Conclusion

From the findings and discussion of MCSML with the urgency of analytical representation and magic card science experiments in the high category compared to CL with a moderate category. As for the level of effectiveness of MCSML in the effective category and CL in the ineffective category used in learning, it means that there is an increase categorized according to Hake's criteria. The increase in criteria occurs in several aspects of problem-solving. The increase in problem-solving aspects is in the category of almost all aspects of problem-solving. The latest acquisition is by Naval Research that the use of magic science media in learning has a positive impact on student learning outcomes.

1. G. S. Selçuk, S. Çahşkan and M. Erol, The effects of problem solving instruction on physics achievement, problem solving performance and strategy use, *Lat. Am. J. Phys. Educ.* **2** (2008) 151, https://www.lajpe.org/sep08/01_Gamze_Sezgin.pdf.
2. T. Gök and I. Silay, The effects of problem solving strategies on students' achievement, attitude and motivation, *Lat. Am. J. Phys. Educ.* **4** (2010) 7, https://dialnet.unirioja.es/descarga/articulo/3694877.pdf.
3. L. D. Bentley and J. L. Whitten, Systems analysis and design for the global enterprise, (McGraw-Hill/Irwin New York, 2006).
4. J. L. Docktor and J. P. Mestre, Synthesis of discipline-based education research in physics, *Phys. Rev. ST Phys. Educ. Res.* **10** (2014) 020119, https://doi.org/10.1103/PhysRevSTPER.10.020119.
5. E. Demiray, Problems in women's education in Turkey. Implementations and suggested solutions, *International Journal on New Trends in Education and Their Implications* **6** (2015) 1, https://www.ijonte.org/FileUpload/ks63207/File/01a.demiray.pdf.
6. J. D. Cutnell and K. W. Johnson, Physics: Probeware Lab Manual, 6th ed. (John Wiley & Sons, New Jersey, USA, 2004) https://archive.org/details/physicslaborator0000john?view=theater&ui=embed&wrapper=false.
7. T. Firdaus,W. Setiawan, and I. Hamidah, The Kinematic Learning Model using Video and Interfaces Analysis, *J. Phys.: Conf. Ser.* **895** (2017) 012108, https://doi.org/10.1088/1742-6596/895/1/012108.
8. A. Pujianto, Analisis Konsepsi Siswa Pada Konsep Kinematika Gerak Lurus, *JPFT* **1** (2013) 16, https://dx.doi.org/10.22487/j25805924.2013.v1.i1.2370.
9. H. I. R. Mosey and B. M. Lumi, Penentuan Percepatan Gravitasi LokalL di Universitas Sam Ratulangi Manado Berdasarkan Teori Getaran Harmonik, *Jurnal Ilmiah Sains* **16** (2016) 104-107, https://doi.org/10.35799/jis.16.2.2016.15150.
10. N. Imtinan and H. Kuswanto, The Use of Phyphox Application in Physics Experiments: A Literature Review, *JIPF* **8** (2023) 183, https://doi.org/10.26737/jipf.v8i2.4167.
11. R. Sebastian, et al., Earth Gravity Detection System with Altitude Variations Using Phypox Application Integrated with Smartphone Acoustic Sensors, *Jurnal Ilmiah Pendidikan Fisika Al-Biruni* **12** (2023) 43, https://doi.org/10.24042/jipfalbiruni.v12i1.15462.
12. R. E. Mayer, Constructivism as a Theory of Learning Versus Constructivism as a Prescription for Instruction, *In Constructivist Instruction* (Routledge, 2009) pp. 196-212.
13. A. S. Isnanto, A. Maftukhin, and E. S. Kurniawan, Pengaruh Penggunaan Alat Peraga Berbasis Lingkungan (APBL) pada Materi Dinamika Partikel terhadap Kemampuan Psikomotor P1 Peserta Didik Kelas X SMA Negeri 1 Kutowinangun, Radiasi: *Jurnal Berkala Pendidikan Fisika* **4** (2014) 30, https://jurnal.umpwr.ac.id/index.php/radiasi/article/view/410.
14. A. Prasetyarini, S. D. Fatmaryanti, and R. W. Akhdinirwanto, Pemanfaatan alat peraga IPA untuk peningkatan pemahaman konsep fisika pada siswa SMP Negeri I Buluspesantren Kebumen tahun pelajaran 2012/2013, RADIASI: *Jurnal berkala pendidikan fisika* **2** (2013) 7, https://jurnal.umpwr.ac.id/index.php/radiasi/article/view/370.
15. M. Munawar *et al*., Efektivitas Penggunaan Media Alat Peraga Terhadap Tingkat Pemahaman Siswa pada Materi Sistem Ekskresi di SMA Negeri 1 Watopute, *KULIDAWA* **1** (2020) 6, https://core.ac.uk/download/pdf/322598225.pdf.
16. A. R. Aththibby and D. H. Alarifin, Pengaruh Permainan dalam Pembelajaran Fisika Terhadap Motivasi Belajar Peserta Didik, *Jurnal Riset dan Kajian Pendidikan Fisika* **2** (2015) 38, https://doi.org/10.12928/jrkpf.v2i2.3246.
17. M. Erintina, Pengaruh Model Pembelajaran Expository Berbantuan Alat Peraga Terhadap Hasil Belajar Fisika Siswa Kelas VIII SMPN 21 Mataram Tahun Pelajaran 2014/2015, *Ganec Swara* **9** (2015) 140, https://unmasmataram.ac.id/wp/wp-content/uploads/24.-Melinda-Dwi-Erintina.pdf.
18. R. I. Greenberg, Educational Magic Tricks Based on Error-Detection Schemes, In Proceedings of the 2017 ACM Conference on Innovation and Technology in Computer Science Education, ITiCSE '17, https://doi.org/10.1145/3059009.3059034.
19. S. Bagienski and G. Kuhn, The crossroads of magic and well-being: A review of wellbeing-focused magic programs, empirical studies, and conceivable theories, *International Journal of Wellbeing* **9** (2019), https://doi.org/10.5502/ijw.v9i2.740.
20. I. Tarjiah, E. Kurniawan, and R. Bagaskorowati, Magical science sebagai media pembelajaran IPA berbasis website untuk siswa tunarungu, *JPK* **16** (2020) 35, https://journal.uny.ac.id/index.php/jpk/article/view/31285.
21. J. Lehrer, Magic and the brain: Teller reveals the neuroscience of illusion, *Wired Magazine* **17** (2009) 90, https://www.wired.com/2009/04/ff-neuroscienceofmagic/.
22. S. Martinez-Conde and S. L. Macknik, Magic and the Brain: How Magicians "Trick" the Mind *Scientific American* **299** (2008) 72.
23. P. Lamont, J. M. Henderson, and T. J. Smith, Where Science and Magic Meet: The Illusion of a "Science of Magic", *Rev. Gen. Psychol.* **14** (2010) 16, https://doi.org/10.1037/a0017157.
24. M. Sanders, The Poetry of Chartism Aesthetics, Politics, History (Cambridge University Press, 2009), https://doi.org/10.1017/CBO9780511576195.
25. G. Kuhn, A. A. Amlani, and R. A. Rensink, Towards a science of magic, *Trends Cogn. Sci.* **12** (2008) 349, https://doi.org/10.1016/j.tics.2008.05.008.

26. S. L. Macknik *et al.*, Attention and awareness in stage magic: turning tricks into research, *Nat. Rev. Neurosci.* **9** (2008) 871, https://doi.org/10.1038/nrn2473.
27. M. Vollmer and K.-P. Möllmann, Ring Falling into a Chain: No Magic-Just Physics, *Phys. Teach.* **49** (2011) 335, https://doi.org/10.1119/1.3628253.
28. J.W. Creswell and C. N. Poth, Qualitative inquiry and research design: Choosing among five approaches, 5th ed. (Sage, 2016) https://us.sagepub.com/en-us/nam/qualitative-inquiry-and-research-design/book266033.
29. J. L. Docktor *et al.*, Assessing student written problem solutions: A problem-solving rubric with application to introductory physics, *Phys. Rev. Phys. Educ. Res.* **12** (2016) 010130, https://doi.org/10.1103/PhysRevPhysEducRes.12.010130.
30. D. E. Meltzer, The relationship between mathematics preparation and conceptual learning gains in physics: A possible "hidden variable" in diagnostic pretest scores, *Am. J. Phys.* **70** (2002) 1259, https://doi.org/10.1119/1.1514215.
31. R. R. Hake, Interactive-engagement versus traditional methods: A six-thousand-student survey of mechanics test data for introductory physics courses, *Am. J. Phys.* **66** (1998) 64, https://doi.org/10.1119/1.18809.
32. J. Hedin *et al.*, The MAGIC meteoric smoke particle sampler, *J. Atmos. Sol.-Terr. Phys.* **118** (2014) 127, https://doi.org/10.1016/j.jastp.2014.03.003.
33. S. Lee, Y. il Choi, and S.-W. Kim, Roles of emotions induced by immediate feedback in a physics problem-solving activity, *Int. J. Sci. Educ.* **43** (2021) 1525, https://doi.org/10.1080/09500693.2021.1922778.
34. B. R. Hergenhahn and M. H. Olson, Theories of Learning, 7th ed. (Kenkana, Indonesia, 2010) https://103.44.149.34/elib/assets/buku/Teori_belajar.pdf.
35. B. C. George, General psychology (Shippensburg University, Yogyakarta, 2008).
36. L. Sarwi, Penumbuhkembangkan keterampilan berpikir kritis calon guru fisika melalui penerapan strategi kooperatif dan pemecahan masalah pada konsep gelombang, *Jurnal Forum Kependidikan* **30** (2010) 37, https://lib.ui.ac.id/m/detail.jsp?id=20409171&lokasi=lokal.
37. M. Hosnan, Pendekatan saintifik dan kontekstual dalam pembelajaran abad 21: Kunci sukses implementasi kurikulum 2013 (Ghalia Indonesia, 2014).
38. L. Yuliati and P. Parno, Exploration of Physics Problem- Solving Skills Within Phenomenon-Based Learning in Senior High School Students, *Proceedings of the International Conference on Education* **4** (2018) 97-103, https://doi.org/10.17501/icedu.2018.4111.
39. L. Yuliati, C. Riantoni, and N. Mufti, Problem Solving Skills on Direct Current Electricity through Inquiry-Based Learning with PhET Simulations., *Int. J. Instr.* **11** (2018) 123.