PENGEMBANGAN MULTI-STRATEGI PEMBELAJARAN UNTUK MENINGKATKAN KETERAMPILAN KOMUNIKASI SAINS PADA MAHASISWA CALON GURU FISIKA

DISERTASI

Diajukan untuk Memenuhi Sebagian Syarat
untuk Memperoleh Gelar Doktor Kependidikan
dalam Bidang Pendidikan Ilmu Pengetahuan Alam

oleh
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Universitas Pendidikan Indonesia

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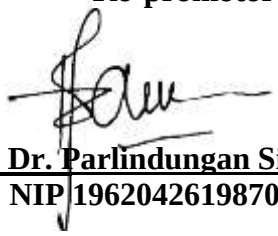

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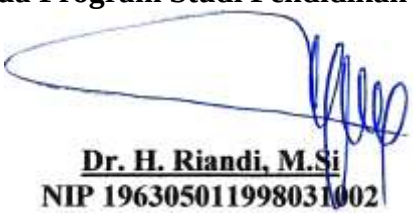

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PERNYATAAN

Dengan ini saya menyatakan bahwa Disertasi dengan judul "Pengembangan Multi-Strategi Pembelajaran Untuk Meningkatkan Keterampilan Komunikasi Sains Pada Mahasiswa Calon Guru Fisika Melalui Perkuliahan Pendalaman Fisika Sekolah" beserta seluruh isinya adalah benar-benar karya saya sendiri. Saya tidak melakukan penjiplakan atau pengutipan dengan cara-cara yang tidak sesuai dengan etika ilmu yang berlaku dalam masyarakat keilmuan. Atas pernyataan ini, saya siap menanggung resiko/sanksi yang dijatuhkan kepada saya apabila di kemudian hari ditemukan adanya pelanggaran etika keilmuan dalam karya saya ini, atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

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KATA PENGANTAR

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Penelitian disertasi ini dilatarbelakangi oleh adanya kebutuhan untuk mengembangkan strategi pembelajaran untuk meningkatkan keterampilan komunikasi sains bagi mahasiswa calon guru fisika. Multi-strategi yang dikembangkan yang terdiri dari strategi membaca buku teks fisika, strategi merepresentasi konsep fisika dan strategi menulis materi ajar multimodus representasi dibutuhkan untuk memandu mahasiswa calon guru fisika agar memiliki keterampilan komunikasi dalam sains. Harapan penulis, proses dan hasil-hasil yang diperoleh dari penelitian disertasi ini dapat memberikan manfaat yang sebesar-besarnya, baik manfaat teoritis bagi perkembangan ilmu pengetahuan dalam bidang pendidikan sains, maupun manfaat secara praktis yakni sebagai bahan masukan dan pertimbangan bagi lembaga penyelenggara pendidikan calon guru fisika untuk menerapkan stategi-strategi pembelajaran yang telah dikembangkan sehingga dapat membekalkan keterampilan komunikasi sains pada mahasiswa calon guru fisika.

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Penulis

PENGEMBANGAN MULTI-STRATEGI UNTUK MENINGKATKAN KETERAMPILAN KOMUNIKASI SAINS PADA MAHASISWA CALON GURU FISIKA MELALUI PERKULIAHAN PENDALAMAN FISIKA SEKOLAH

ABSTRAK

Beberapa negara telah menetapkan komunikasi yang efektif sebagai sub-tema dari keterampilan profesional guru berkualitas. *Partnership for 21st century skills* telah menetapkan bahwa keterampilan komunikasi adalah bagian dari keterampilan abad ke-21. Komunikasi berkaitan erat dengan bahasa. Bahasa sains mengandung komponen verbal (tipologis), matematis, visual-grafis, dan aksi operasional (topologis), oleh karena itu komunikasi dalam sains mengandung komponen verbal (tipologis), matematis, visual-grafis, dan aksi operasional (topologis). Guru sains perlu menguasai keterampilan komunikasi sains dengan baik. Keterampilan komunikasi sains perlu dilatihkan kepada mahasiswa calon guru selama masa studinya. Keterampilan komunikasi sains yang terpantau masih lemah pada mahasiswa calon guru fisika di sebuah LPTK di Bandung adalah keterampilan membaca buku teks fisika dengan tingkat pemahaman mendalam (*deep level comprehension*), keterampilan merepresentasi konsep fisika dan keterampilan menulis materi ajar multimodus representasi. Penelitian ini bertujuan mengembangkan stategi membaca buku teks fisika, merepresentasi konsep fisika dan menulis materi ajar multimodus representasi. Dengan menerapkan strategi-strategi tersebut diharapkan mahasiswa calon guru fisika mampu membaca buku teks fisika dengan tingkat pemahaman mendalam, menyajikan konsep dan hukum fisika dalam modus teks dan visual; mentranslasi antar modus representasi, menjelaskan konsep fisika dalam multi representasi dan mempertimbangkan representasi akan kelayakannnya dalam merepresentasikan konsep fisika secara visual dan menulis materi ajar fisika yang di dalamnya menyajikan gabungan dua atau lebih modus representasi. Metoda yang digunakan dalam penelitian ini adalah metoda penelitian dan pengembangan (*Research and Development Methods*). Tahap-tahap yang dilakukan dalam penelitian ini meliputi studi pendahuluan, perencanaan, mengembangkan rancangan strategi pembelajaran, ujicoba pendahuluan, merevisi produk dan ujicoba utama. Dengan menggunakan metode R & D telah dikembangkan multi-strategi untuk meningkatan keterampilan komunikasi sains. Multi-strategi tesebut terdiri dari strategi membaca buku teks fisika yaitu *Reading Strategy Quadrant* (RSQ), strategi merepresentasi konsep fisika yaitu *Representation Pedagogical Content Knowledge Strategy* (RPCK-Strategy) dan strategi menulis materi ajar multimodus representasi yaitu *Triple Step Writing Strategy* (TS-WS). Ujicoba pendahuluan (*pleriminary field testing*) menggunakan metode *pre-experiment* desain *the one group pretest-posttest design*. Ujicoba utama (*main field testing*) menggunakan metode *quasi-expeiment* desain *randomized pretest-posttest control group design.* Multi-strategi tersebut sudah diujicobakan pada mahasiswa calon guru fisika yang berusia rata-rata 21 tahun pada sebuah LPTK di Bandung. Ujicoba pendahuluan melibatkan 15 mahasiswa calon guru fisika dan ujicoba utama 45 mahasiswa calon guru fisika. Instrumen untuk mengukur keterampilan membaca buku teks fisika adalah tes uraian keterampilan membaca buku teks fisika dan tes pemahaman konsep listrik statis. Instrumen untuk mengukur keterampilan merepresentasi konsep fisika adalah tes uraian keterampilan merepresentasi konsep listrik statis dan tes pemahaman konsep listrik statis.

Untuk mengukur keterampilan menulis materi ajar multimodus representasi mahasiswa ditugaskan untuk menulis materi ajar multimodus representasi. Hasil penelitian menunjukkan bahwa: 1) RSQ efektif dalam meningkatkan keterampilan membaca buku teks fisika pada materi listrik statis dan efektif dalam meningkatkan pemahaman konsep listrik statis, 2) RPCK *Strategy* efektif dalam meningkatakan keterampilan merepresentasi konsep listrik statis dan efektif dalam meningkatkan pemahaman konsep listrik statis dan 3) TS-WS efektif dalam meningkatkan keterampilan menulis materi ajar multimodus representasi mahasiswa calon guru fisika.

Kata kunci: keterampilan komunikasi sains, membaca buku teks fisika, merepresentasi konsep fisika, menulis materi ajar multimodus representasi

DEVELOPMENT OF MULTI-STRATEGIES TO IMPROVE SCIENCE COMMUNICATION SKILLS ON PRESERVICE PHYSICS TEACHERS THROUGH *PENDALAMAN FISIKA SEKOLAH* COURSE

ABSTRACT

Several countries have established effective communication as a sub-theme of the quality of professional teacher skills. *Partnership for 21st century skills* has established that communication skills are part of 21st century skills. Communication is closely related to language. The language of science contains verbal (typological), mathematical, visual-graphic, and operational (topological) components, therefore communication in science contains verbal (typological), mathematical, visual-graphic, and operational (topological) components. Science teachers need to master science communication skills well. Science communication skills need to be taught to preservice teacher during their studies. Science communication skills possessed by preservice physics teachers students at a LPTK in Bandung that are still weak include the skills of reading physics textbooks with a deep level comprehension, the skills of representing physical concepts and the skill of writing multimodal representation teaching material. This study aims to develop strategies to read physics textbooks, represent physics concepts and write multimodal representations teaching materials. By implementing these strategies, it is expected that preservice physics teachers are able to read physics textbooks with a deep level comprehension, present concepts and laws of physics in text and visual modes; translate among modes of representation, explain the concepts of physics in multiple representations and consider representations of their feasibility in representing physical concepts visually; and write physics teaching materials which present a combination of two or more modes of representation. The method used in this research is Research and Development (R & D) methods. The stages of R & D methods carried out in this study include research and information collecting activities, planning activities, developing learning strategy designs, preliminary field testing, main product revision and main field testing. Using the R & D method, a multi-strategy has been developed to improve science communication skills. Using the R & D method, a multi-strategies has been developed to improve science communication skills. The multi-strategies consists of a physics textbook reading strategy called the Reading Strategy Quadrant (RSQ), a strategy of representing physics concepts called the Pedagogical Representation Content Knowledge Strategy (PRCK-Strategy) and a strategy for writing multimodal representations teaching materials called the Triple Step Writing Strategy (TS-WS). Pleriminary field testing used the one group pretest-posttest design pre-experiment method. Main field testing used a quasi-expeiment design randomized pretest-posttest control group design method. The multi-strategies has been tested on preservice physics teachers who were on average 21 years old at an LPTK in Bandung. The preliminary field testing involved 15 preservice physics teacher and the main field testing was 45 preservice physics teacher. Instruments that is used to measure physics textbook reading skills is an essay test of the skills of reading a textbook in physics and a test for understanding the concept of static electricity. Instrument that is used to measure the skills to represent the concepts of physics is an essay of the skills representing the concept of static electricity and a test of understanding the concept of static electricity. To measure the skills of writing multimodus representation teaching

materials students are assigned to write multimodus representation teaching materials. The results showed that: 1) RSQ was effective in improving the reading skills of physics textbooks on static electricity and was effective in increasing the understanding of static electricity concepts, 2) PRCK Strategy was effective in increasing skills in representing static electricity concepts and was effective in increasing understanding of static electricity concepts and 3) TS-WS was effective in improving the skill of writing multimodal representations of teaching materials for preservice physics teachers.

Keywords: science communication skills, read physics textbook skills, represent physics concepts skills, write multimodal representations teaching materials skills

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DAFTAR PUSTAKA

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Afflerbach, P., Cho, B. Y., & Kim, J. Y. (2015) Conceptualizing and Assessing Higher-Order Thinking in Reading. *Theory Into Practice*. 54(3), 203-212

Ainsworth, S. (1999). The functions of multiple representations. *Computer & Education, 33,* 131–152.

Ainsworth, S., & Van Labeke, N. (2004). Multiple forms of dynamic representation. *Learning and Instruction, 14*, 241–255

Ainsworth, S. (2006). DeFT: A conceptual framework for considering learning with multiple representations. *Learning and Instruction, 16,* 183–198.

Ainsworth, S., Prain,V., & Tytler, R. (2011). Drawing to Learn in Science, SCIENCE Vol. 13. Tersedia di www.sciencemag.org

Airey, J., & Linder, C. (2009). A disciplinary discourse perspective on university science learning: Achieving fluency in a critical constellation of modes. *Journal of Research in Science Teaching*, *46*(1), 27–49.

Alexander, P.A., & Jetton, T.L. (2000). Learning from text: A multidimensional and developmental perspective. In M.L. Kamil, P.B. Mosenthal, P.D. Pearson, & R. Barr (Eds.), *Handbook of reading research, 3,* 285–310. Mahwah, NJ: Erlbaum.

Anderson, N.J. (1991). Individual differences in strategy use in second language reading and testing. *Modern Language Journal*, 75(4):460-472

Bhattacharyya, G., & Bodner, G.M. (2005)." It gets me to the product": How students propose organic mechanisms. *Journal of Chemical Education*

Bereiter, C & Scardamlia, M. (2013). The psychology of written composition. Routledge

Bernhardt, E. B. (2000) Second-language reading as a case study of reading scholarship in the 20th century. Dalam M. L Kamil, P. B Mosenthal, P D. Pearson & R. Barr (Eds). Handbook of Reading Reserch, 3, 719-81, Malwah NJ.L Erlbaum Asoc.

Berthold, K., Eysink, T.H.S. & Renkl. (2009). Assisting self-explanation prompts are more effective than open prompts when learning with multiple representations. *Instr Sci* 37**,** 345–363

Best, R. M., Rowe, M., Ozuru, Y., McNamara, D. (2005). Deep-Level Comprehension of Science Texts: The Role of the Reader and the Text, 25(1), 65-83

Bezemer, J. & Kress, G. (2008). Writing in Multimodal Texts A Social Semiotic Account of Designs for Learning. *Written Communication*, 25(2), 166-195

Bosse, M.J., Gyamfi,K.A., & Cheetham, M (2011) Translations Among Mathematical Representations: Teacher Beliefs and Practices, Departme of Mathernatics, Science, and Instruction Technology Education, College Education, East Carolina University, Greenville, NC 28590

Carolan, J., Prain, V., Baldrip, B. (2008).Using representations for teaching and learning in science. Tersedia di blogs.deakin.edu.au

Carnine, L., & Carnine, D. (2004). The interaction of reading skills and science content knowledge when teaching struggling secondary students. *Reading & Writing Quarterly*, 20, 203-218.

Chan K.K., Burtis, P.J., Bereiter, C & Scardamlia, M. (1992). Constructive Activity in Learning From Text. *American Educational Research Journal*, 29(1), 97-118

Chang, H.Y., & Tzeng, S. F. (2018). Investigating Taiwanese students' visualization competence of matter at the particulate level. *International Journal of Science and Mathematic*

Clark, J.M & Paivo, A. (1991). Dual Coding Theory and Education. Educational Psychology Review, 3(3), 149-210

Chittleborough, G.D.,Treagust, D., Goldman, S. R., Golden, R. M., & Van den Brock, P. (2007) Why are computational models of text comprehension useful? Dalam F. Schmalhoefer & C. Perfetti (Eds.), *Higher Level Language Processes in the Brain: Inference and Comprehension Processes* (p.27-51) Mahwah, NJ: Erlbaum.

Chittleborough, G.D., &Treagust, D. (2007).The modeling ability of non-major chemistry Students and their understanding of the sub-microscopic level. DOI: 10.1039/B6RP90035F

Cohen, M. & Riel, M. (1989). The effect of distant audiences on students' writing. *American Educational Research Journal* 26 (2), 143-159, 1989

Cohen, Jacob. (1988).Statistical Power Analysis for the Behavioral Sciences. Lawrence Erlbaum Associates

Cohen, L., Manion, L., and Morrison, K. (2007). *Research Methods in Education*. USA and Canada: Routledge

Cook, L.K., & Mayer, R.E. (1988). Teaching Readers About the Structure of Scientific Text. *Journal of Educational Phychology*, 80 (4), 448-456

Das, K. (2014). Need of Effective Communication Skills in Teaching Science in. *International Journal of Educational Research and Technology*, *5*(September), 40–42.

de Carvalho. (2002). Communication skills for teaching, 1–16.

de Jong, T & van Joolingen, W.R. (1998). Scientific Discovery Learning with Computer Simulation of Conceptual Domains. Review of Educational Research, 68, (2), 179-201

Demirbag, M., & Gunel, M. (2014). Integrating Argument-Based Science Inquiry with Modal Representations: Impact on Science Achievement, Argumentation, and Writing Skills. *Educational Sciences: Theory & Practice*, 14(1), 386-391

diSessa, A. (2004). Metarepresentation: Native competence and targets for instruction. *Cognition and Instruction, 22(3), 293–331*

diSessa, A., & Sherin, B. (2000). Meta-representation: An introduction. *Journal of Mathematical Behavior*, 19, 385–398

Dreyfus, S. E., & Dreyfus, H. L. (1980). A five-stage model of the mental activities involved in directed skill acquisition. Tersedia di http://www.sld.demon.co.uk/dreyfus.pdf

Eilam, B., Poyas, Y., Hashimshoni, R., (2014). Representing Visually: What Teachers Know and What They Prefer. Dalam Eilam, B. dan Gilbert, J.K (Ed) *Science Teachers' Use of Visual Representations*. Springer

Eilam, B. (2012a). Teaching, learning, and visual literacy: The dual role of visual representation in the teaching profession. New York: Cambridge University Press

Erduran, S., Ozdem, Y., & Park, J. Y. (2015). Research Trends on Argumentation in Science Education : a Journal Content Analysis from 1998-2014. *International Journal of STEM*, 1–12.

Etkina, E., Rosengrant, D., & Van Heuvelen, A. (2008) Using multiple representations to improve student learning in mechanics. In Advanced Placement Special Focus: Multiple Representations of Knowledge: Mechanics and Energy. College Board (3-25).

Fang, Z., & Wei, Y. (2010). Improving middle school students' science literacy through reading infusion. The Journal of Educational Research, 103, 262-273.

Fraenkel, J.R & Wallen, N.E. (2006). *How to Design and Evaluate Research in Education.* New York: Mc. Grow Hill Pub Co

Fredlund, T., Airey, J., & Linder, C. (2012). Exploring the role of physics representations: An illustrative example from students sharing knowledge about refraction. *European Journal of Physics*, 33, 657–666

Fuch, D., & Fuch, L.S. (2007). Increasing Strategic Reading Comprehension With Peer-Assisted Learning Activities. Dalam McNamara, D. S. (Ed.). *Reading Comprehension Strategies*. Lawrence Erlbaum Associates, Inc.

Gagne, M.R. (1970). The Conditions of Learning. USA: Graw-Hill Publishing

Gambrell, L. B., & Jaywitz, P. B. (1993). Mental imagery, text illustrations and children's story comprehension and recall. *Reading Research Quarterly, 28*, 265–273.

Gilbert, J. K., & Treagust, D. (2009). Introduction: Macro, submicro and symbolic representations and the relationship between them: Key models in chemical education. Dalam J. K. Gilbert & D. Treagust (Ed), *Multiple representations in chemical education* . Dordrecht: Springer

Gilbert, J. K., Boulter, C. J., & Rutherford, M. (2000). Explanations with Models in Science Education. Dalam Gilbert, J.K., & Carolyn J. Boulter (Ed), *Developing Models in Sciene Education*. Dordrecht: Kluwer Academics Publishers

Gillis, V.R., & MacDougall, G. (2007). Reading to Learn Science as an Active Process: Using learning cycles in the classroom can actively engage students in thinking, talking, reading, and writing about science.*The Science Teacher*,74 (5), 45-50.

Goodman, K. (1967). Reading A psycholinguistic guessing game. *Journal of the Reading Specialist,* 6(4), 126-135

Goodman (1982). Language and Literacy The Selected Writigs of Kemneth S Goodman. Boston and London: Routledge Kegan & Paul

Gough, P. B. (1972) One second of reading. Dalam J. F. Kavanagh & L.G. Mattingly (Eds.), *Language by ear and by eye* (pp. 331-358). Cambridge, MA: MIT Press.

Glynn, S. M., & Muth, K. D. (1994). Reading and Writing to Learn Science : Achieving Scientific Literacy. *Journal Of Research in Science Teaching*, *31*(9), 1057–1073.

Göksoy, S. (2014). Teacher Candidates' (Pedagogical Formation Students) Communication Skills. *Creative Education*, (August), 1334–1340.

Grabe, W. (2009). Reading in a second language: Moving fromtheory to practice. Cambridge: New York: Cambridge University

Goodman. (1982). Language and Literacy: The Selected Writing of Kenneth S. Goodman. Boston: Routledge Kegan & Paul

Graesser, A.C. (2007). An introduction to strategic reading comprehension. Dalam D. McNamara (Ed.). *Theories of text comprehension: The importance of reading*

Graesser, A. C., & Forsyth, C. (2012, in press). Discourse comprehension. Dalam D. Reisberg (Ed.), *Oxford handbook of cognitive psychology*. Oxford, U.K: Oxford University Press.

Graesser, A. C., Millis, K. K., & Zwaan, R.A. (1997). Discourse comprehension. *Annual Review of Psychology*, 46, 163-189.

Graesser, A.C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review*, 101(3), 371-395.

Graesser, A.C., & Whitten, S. (2000). Review of Walter Kintsch's book. "Comprehension: A paradigm in cognition". *Journal of Pragmatics*, 32. 1247-1252

Greca, M & Moreira, M.A,. (1997). The kinds of mental representations--models, propositions and images--used by college physics students regarding the concept of field I - *International Journal of Science Education*

Gunel, M., & Yesildag-Hasancebi, F. (2016). Modal representations and their role in the learning process: A theoretical and pragmatic analysis. E*ducational Sciences: Theory & Practice*, 16, 109-126

Gunel M., Hand, B., Gunduz, S. (2006). Understanding of Quantum Physics When Embedding Multimodal Representations into Two Different Writing Formats: Presentation Format Versus Summary Report Format. *Science Education*, 90:1092–1112

Gunstone, R., Mulhall, P. & McKittrick, B., (2009). 'Physics teachers' perceptions of the difficulty of teaching electricity', *Research in Science Education* 39(4), 515–538.

Halliday, M. A. K. (1993). On the language of physical science. In M. A. K. Halliday & J. R. Martin (Eds.), *Writing science: Literacy and discursive power* (pp. 54–68). Pittsburgh: University of Pittsburgh Press.

Hake, R.R. (1998). Interactive-engagement vs traditional method: A six-thousand students survey of mechanic test data for introductory physics course. *American Journal of Physics*, 66, 64-74

Hand, B., Gunel, M., & Ulu, C. (2009). Sequencing Embedded Multimodal Representations in a Writing to Learn Approach to the Teaching of Electricity . *Journal of Research in Science Teaching*. 46 (3), 225–247

Hand, B., & Choi, A. (2010). Examining the impact of student use of multiple modal representations in constructing arguments in organic chemistry laboratory classes. *Research in Science Education*, *40*, 29–44.

Handayani, W., Setiawan, W., Sinaga, P., & Suhandi, A. (2018). Students' reading comprehension skills of science and physics texts. *Jurnal Inovasi Pendidikan IPA, 4*(2), 203-211

------(2019). Translation Among Modes Of Representation By Pre-Service Physics Teacher On Magnetic Force On Particle Concept. *IOP Conf. Series:Journal of Physics*: Conf. Series **1157** (2019) 032058

Hayes, J. R., & Flower, L. (1986). Writing research and the writer. *American Psychologist*, 41, 1106–1113

Harison, A. & Treagust, D. (1998). Modelling in science lessons: Are there better ways to learn with models? . *School Science and Mathematics* 98 (8), 420-429, 1998

Hedgcock, J.S & Ferris, D.R. (2009). *Teaching Readers of English: Students, texts, and contexts*. New York: Routledge

Hill, M., Sharma, M. D., & Johnston, H. (2015). How Online Learning Modules Can Improve The Representational Fluency And Conceptual Understanding Of University Physics Students. *European Journal of Physics*

Hubber, P., Tytler, R., & Haslam, F. (2010). Teaching and learning about force with a representational focus: Pedagogy and teacher change. *Research in Science Education*, 40(1), 5–28.

Hurd, M.J. (2000).The Transformation of Scientific Communication: A Model for 2020. *Journal Of The American Society For Information Science*. 51(14):1279–1283

Jennings, C. M., Jennings, J. E., Richey, J., & Dixon-Krauss, L. (1992). Increasing interest and achievement in mathematics through children's literature. *Early Childhood Research Quarterly*, 7(2), 263–267

Johnstone, K. M., Ashbaugh, H., & Warfield, T. D. (2002). Effects of repeated practice and contextual-writing experiences on college students' writing skills. *Journal of Educational Psychology, 94*, 305-315.

Johnson, B. E., & Zabrucky, K. M. (2011). Improving middle and high school students ' comprehension of science texts. *International Electronic Journal of Elementary Education*, *4*(1), 19–31.

Johnson-Glenberg, M. C. (2000). Training reading comprehension in adequate decoders/poor comprehenders: Verbal vs. visual strategies. *Journal of Educational Psychology*, *92*, 772–782

Johnson, A. M et al. (2013). Learning from abstract and contextualized representations: The effect of verbal guidance. *Computers in Human Behavior*, 29, 2239–2247

Johnson, A. M., Butcher, K. R., Ozogul, G., Reisslein, M. (2013) Learning from abstract and contextualized representations: The effect of verbal guidance. *Computers in Human Behavior*, 29 (2013) 2239–2247

John S. Hedgcock, J. S., Ferris, D., N., (2011). Teaching Readers of English: Students, Texts, and Contexts. Reaserchgate

Kellogg, R.T. (2008). Training writing skills: A cognitive developmental pers-pective. *Journal of writing research, 1*(1), 1-26

Kendeou, P., Rapp, D. N., & van den Broek, P. (2003). The influence of reader's prior knowledge on text comprehension and learning from text. In R. Nata (Ed.), *Progress in Education, Vol.13* (pp 189-209). Nova Science Publishers, Inc: New York.

Kress, G., Jewitt, C., Ogborn, J., & Tsatsarelis, C. (2001). *Multimodal teaching and learning: The rhetorics of the science classroom*. London, UK: Continuum

Keys, C. W., Hand, B., Prain, V., & Collins, S. (1999). Using the Science Writing Heuristic as a tool for learning from laboratory investigations in secondary science. Journal of Research in Science Teaching, 36, 1065–1084

Klapwijk, N.M., (2015), EMC² = comprehension: A reading strategy instruction framework for all teachers. South African Journal of Education, 35(1)

Kintsch, W. (1974). The representation of meaning in memory. Hillsdale, NJ: Erlbaum.

-----. (1988). The role of knowledge in discourse comprehension construction-integration model. *Psychological Review*, 95, 163-182.

-----. (1998). Comprehension: A paradigm for cognition. New York: Cambridge University Press.

Koch, A. (2000). *Training in Metacognition and Comprehension of Physics Texts*. (R. Gunstone & R. White, Eds.). JohnWiley & Sons, Inc.

Koch, A., & Eckstein, S. G. (1991). Improvement of reading comprehension of physics texts by students' question formulation. *International Journal of Science*, (July

2013), 37–41.
Kohl P.B., & Finkelstein N,D. (2017) Understanding and Promoting Effective Use of Representations in Physics Learning. Dalam Treagust D., Duit R., Fischer H. (eds). *Multiple Representations in Physics Education. Models and Modeling in Science Education*. Vol 10. Springer
-----. (2006a). The effect of instructional environment on physics students representational skills. *Phys. Rev. ST Phys. Educ. Res*
-----. (2006b). The effects of representation on students solving physics problems: a fine-grained characterization. *Phys. Rev. ST. Phys. Educ. Res.*
Kozma, R., & Russell, J. (1997). Multimedia and understanding: Expert and novice responses todifferent representations of chemical phenomena. *Journal of Research in Science Teaching*, 34(9), 949–968.
Lemke, J. L. (1998b). "Multiplying Meaning: Visual and Verbal Semiotics in Scientific Text." In *Reading Science* . Tersedia di http://academic.brooklyn.cuny.edu/education/jlemke/papers/mxm-syd.htm
Leopold, C & Leutner, D. (2012) Science text comprehension: Drawing, main idea selection, and summarizing as learning strategies. *Learning and Instruction, 22, 16-26*
Leopold, C., & Mayer, R. E. (2014, June 16). An Imagination Effect in Learning From Scientific Text. *Journal of Educational Psychology*.
Limpo,T. & Alves, R., A. (2018). Effects of planning strategies on writing dynamics and final texts. *Acta Psychologica*, 188, 97–109
Lynch, M. (2001). Visualization: Representation in science. In N. J. Smelser & P. B. Baltes (Eds.), *International Encyclopedia of the Social and Behavioral Sciences,* pp. 16288-16292.
Maloney, D.P., O'Kuma, T.L., Hieggelke, C.J.,Van Heuvelen, A. (2000). Surveying students' conceptual knowledge of electricity and magnetism. Phys. Educ. Res., Am. J. Phys. Suppl. 69 ~7
Mallet, D.G. (2007) Multiple Representations For Systems Of Linear Equations Via The Computer Algebra System Maple. I*nternational Electronic Journal of Mathematics Education*,Volume 2(1)
Mayer, R. E. (2009). Multimedia Learning Prinsip-Prinsip dan Aplikasi. Surabaya: ITS Press
Mayer, R.E & Moreno, R. (2003) Nine Ways to Reduce Cognitive Load in Multimedia Learning. *Educational Psychologist,* 38:1, 43-52
McColgan,M.W., Finn, R.A., Broder, D. L., & Hassel, G.E. (2017). Assessing Students' Conceptual Knowledge Of Electricity And Magnetism. *Physical Review Physics Education Research*
McCutchen, D. (2011). From Novice to Expert: Implications of Language Skills and Writing-Relevant Knowledge for Memory during the Development of Writing Skill. *Journal of Writing Research*, 3(1), 51-68.
McDermott, M. A., & Hand, B. (2013). The impact of embedding multiple modes of representation within writing tasks on high school students' chemistry understanding. *Instructional Science, 41*, 217–246.
McNamara, D. S. (Ed.). (2007). *Reading Comprehension Strategies*. Lawrence Erlbaum Associates, Inc.

McNamara, D. S., & Kintsch, W. (1996). Learning from texts: Effects of prior knowledge and text coherence. *Discourse Processes*, *22*(3), 247–288

McNamara, D. S. (2009). The importance of teaching reading strategies. *Perspectives on Language and Literacy*, *35*(2), 34.

Meij, J. V. D., & de Jong, T. (2011). The effects of directive self-explanation prompts to support active processing of multiple representations in a simulation-based learning environment. *Journal of Computer Assisted Learning*, 411–423.

Mendiknas. Permendiknas RI No. 16 Tahun 2007 (2007).

Messmann, G., Mulder, R.H. Innovative Work Behaviour in Vocational Colleges: Understanding How and Why Innovations Are Developed. *Vocations and Learning* **4,** 63–84 (2011)

Mete, Filiz. (2015). Domain of Communication Skills in Generic Teachers' Competency: England, Ireland, Australia, Canada and Turkey. *Journal of Education & Social Policy Vol. 2, No. 6*

Miller, G. A. (1956). The magical number seven, plus or minus two: some limits on our capacity for processing information. Psychological Review, 63, 81–97.

Murcia, K. (2010). Multi–modal representations in primary science: What's offered by interactive whiteboard technology. *Teaching Science*, *56*(1), 23–29.

Nakhleh, M. B., & Postek, B. (2008). Learning chemistry using multiple external representations. In J. K. Gilbert, M. Reiner, & M. Nakhleh (Eds.), Visualization: Theory and practice in science education (pp. 209–231). Dordrecht: Springer.

National Research Council. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. Washington, DC: The National Academies Press

National Reading Pane*l*. (2000). Teaching Children To Read: An Evidence-Based Assessment of the Scientific Research Literature on Reading and Its Implications for Reading Instruction

Nersessian. (2008). *Creating Scientific Concepts*. Cambidge: MIT Press

Nichols, K., Stevenson, M., Hedberg, J., & Gillies, M. (2015). Primary teachers' representational practices: from competency to fluency. Cambridge Journal of Education

Nitz, S., Ainsworth, S.E., Nerdel, C., Prechtl, H. (2014). Do student perceptions of teaching predict the development of representational competence and biological knowledge?. *Learning and Instruction*

Norris, S.P., & Philip, L. M. (2003). How literacy in its fundamental sense is central to scientific literacy. *Science education* 87 (2), 224-240, 2003

Novak, J., D & Gowin, D. B. (1984). Learning how to learn. Cambridge: University press

Novak, J. (198). Concept mapping: A useful tool for science education. *Journal Of Research In Science Teaching* 27 (10), 937-949, 1990

Novak, J., D., Gowin, D. B., Johansen, G.T. (1983).The use of concept mapping and knowledge vee mapping with junior high school science students. *Science education*

Oakhill, J., & Patel, S. (1991). Can imagery training help children who have comprehension problems? *Journal of Research in Reading*, *12*, 106–115

Ogborn, J., Kress, G., Martins, I. (1996). Explaining science in the classroom. UK: McGraw-Hill Education

Oliva, P. F., & Henson, K.T. (1980). What are the essential generic teaching competencies? Theory Into Practice, 19:2, 117-121. Tersedia di http://www.tandfonline.com/loi/htip20. Diakses pada 4 Nvember 2016

Oliviera, D.K.B.S., Justi,R., & Mendonca, P.C.C. (2015). The Use of Representa-tions and Argumentative and Explanatory Situations. *International Journal of Science Education*

Olympiou, Zacharias & deJong. (2013). Making the invisible visible: enhancing students' conceptual understanding by introducing representations of abstract objects in a simulation. *Instructional Science*, 41(3), 575–596

Opfermann, Schmeck, & Fischer. (2017). Multiple Representations in Physics and Science Education – Why Should We Use Them? Dalam:, *Multiple Representations in Physics Education*. Treagust, Duit &Fischer (Ed). Switzerland: Springer

O'Reilly & McNamara (2007) The Impact of Science Knowledge, Reading Skill, and Reading Strategy Knowledge on More Traditional "High-Stakes"Measures of High School Students' Science AchievementAmerican Educational Research Journal March 2007, Vol. 44, No. 1, pp. 161–196

Osborn witrock

Ozuru, Dempsey & McNamara, 2009 Prior knowledge, reading skill, and text cohesion in the comprehension of science texts . Learning and Instruction 19 (2009) 228e242

Paivio, A., & Lambert, W. (1981). Dual coding and bilingual memory. Journal of Verbal Learning & Verbal Behavior, 20, 532-539.

Paivio. (1991). Dual coding Theory: Retrospect and current status. Jpurnal Psychology,45, 255-287

Partnership for 21st Century Skills. (2011). Framework for 21st century learning. Tersedia di http://www.p21.org/index. php?option=com_content& task=view &id=254&Itemid=120

Paris S.G., Wasik, B. A & Turner, J.C. (1991). The development of strategic reading. Dalam R Barr, ML Kamil, PB Mosenthal & PD Pearson (eds). *Handbook of Reading Research (Volume II)*. Mahwah, NJ: Lawrence Erlbaum Associates

Peacock, A. (1995) Access to science learning for children in rural Africa. *International Journal of Science Education*, 17 (2), 149-166

Perin, D., & Hare, R. (2010). A contextualized reading-writing intervention for community college students (CCRC Brief No. 44). New York, NY: Community College Research Center, Teachers College, Columbia University. Tersedia di http://ccrc.tc.columbia.edu/Publication .asp?UID=788

Poock, J.,Burke, K., Greenbowe, T.,&Hand, B. (2007).Using the science writing heuristic in the general chemistry laboratory to improve students academic performance. *Journal of Chemical Education*, 84, 1371 – 1378.

Pozzer-Ardenghi, L., & Roth, W. M. (2007). On performing concepts during science lectures. *Science Education*, 91(1), 96–114

Prain, V., & Waldrip, B. (2007). An exploratory study of teachers' and students' use of multi–modal representations of concepts in primary science. *International Journal of Science Education*, 28(*15*), 1843–1866

Pressley, M. (200). Imagery and children's learning: Putting the picture in developmental perspective. *Review of Educational Research*, *47*, 585–622.

Purbaningrum, E & Yuliyati. (2010). Pembelajaran Menulis dengan Pendekatan

Menulis Proses bagi Siswa Tunarungu. *JASSI_Anakku*, 9(1)
Ramsden, J. M. (1997). How does a context-based approach influence understanding of key chemical ideas at 16+?. *International Journal of Science Education*,19(6), 697-710
----------. (1992) If it's enjoyable, is it science? *School Science Review*, 73 (265), 65-71.
Rosengrant, D., Van Heuvelen, A. & Etkina, E. (2009). Do students use and understand free-body diagrams?. *Phys. Rev. Spec. Top.—Phys. Educ. Res*.
Roy M. & Chi M.T.H. (2005). The self-explanation principle in multi-media learning. Dalam: *Cambridge Handbook of Multimedia Learning* . R.E. Mayer (Ed), pp. 271–287. Cambridge University Press, Cambridge, UK.
Rumelhart, DE (1977) Toward and lateractive Model of Reading. Dalam S. Dormi (ed) dno ond Performance I (pp ST-60) New York Acadee Pres
Sampson, V et al. (2013). Writing to Learn by Learning to Write During the School Science Laboratory: Helping Middle and High School Students Develop Argumentative Writing Skills as They Learn Core Ideas. *Science Education*, 97(5),643–670 (2013).
Sawilowsky, Shlomo S. (2009). New Effect Size Rules of Thumb. Journal of Modern Applied Statistical Methods. Tersedia di http://digitalcommons.wayne.edu/jmasm/vol8/iss2/26
Schmeck, A., Mayer, R.E,. Opfermann, M., Pfeiffer, V., Leutner, D. (2014). Drawing pictures during learning from scientific text: testing the generative drawing effect and the prognostic drawing effect. Contemporary Educational Psychology , 9, 275–286
Schmidt, W. H., Cogan, L., & Richard, H. 2011. The role of opportunity to learn in teacher preparation: an international context. *Journal of Teacher Educatio. 62 (2):* 138-153
Schnotz, W., & Bannert, M. (2003). Construction and interference in learning from multiple representation. *Learning and Instruction 13*, 141–156
Schnotz, W., & Lowe, R. (2003). External and internal representations in multimedia learning. *Learning and Instruction*, 13, 117–123.
Schwamborn, A., Thillmann, H.,Opfermann, M (2011). Cognitive load and instructionally supported learning with provided and learner-generated visualizations. Computers in Human Behavior, 27(1), 89-93
Schwartz, D. L. (1995). The emergence of abstract representations in dyad problem solving. *The Journal of the Learning Sciences, 4*, 321-354
Sengupta, S. (2002). Developing academic reading at tertiary level: A longitudinal study tracing conceptual change. *The Reading Matrix*, *2*(1).
Simbolon, M & Sinaga, P. (2015). Analisis Materi Ajar Fisika Yang Digunakan Di SMA Berdasarkan Level Penggunaan Multi Representasi Dan Pembekalan Keterampilan Pemecahan Masalah. Prosiding Simposium Nasional Fisika (SINAFI) 2015
Shulman, L. S. (1986). Those who understand: Knowledge growth in teaching. Educational Researchef .15, 4-14
Slavin. R. E. 2000. Educational Psychology: Theory and Practice. New Jersey : Pearson Education

Smith, F. (1971). Understanding reading A psycholinguistic analysis of reading and learning to read. New York: Holt, Rinehart and Winston.

Sinaga, P. (2015). The Effectiveness of Scaffolding Design in Training Writing Skills Physics Teaching Materials. *International Journal of Instruction*, *8*(1).

----------(2014). *Pengembangan Program Perkuliahan Fisika Sekolah III Untuk Meningkatkan Kompetensi Menulis Materi Ajar Calon Guru Menggunakan Multi Modus Representasi*. Universitas Pendidikan Indonesia (Disertasi Doktor)

Sinaga, P., Suhandi, A. & Liliasari (2014).The Effectiveness Of Learning To Represent Physics Concept Approach: Preparing Pre-Service Physics Teachers To Be Good Teachers. *International Journal of Research in Applied, Natural and Social Sciences*, 2(4), 127-136

Snow, C. E. (2002). Reading for understanding : toward a research and development program in reading comprehension.

Spektor-Levy,O., Eylon, Bat-Sheva,& Scherz. (2009). Teaching Scientific Communication Skills In Science Studies: Does It Make A Difference? International Journal of Science and Mathematics Education (2009) 7: 875-903

Scherz, Z., Spektor-Levy, O.,& Eylon, B. (2008). "Scientific Communication": An Instructional Program For High-Order Learning Skills And Its Impact On Students' Performance. Dalam K. Boersma Et Al. (Ed.), *Research And The Quality Of Science Education*, 231—243. Netherland: Springer

Spence, Yore & Williams. (1999). The effects of explicit science reading instruction on selected grade 7 students' metacognition and comprehension of specific science text. *Journal of Elementary Science Education*

Sweler, J. & Chandler, P. (1994). Why Some Material Is Difficult to Learn. *Cognition and Instruction*, 12(3)

Tang, K., Delgado, C., & Moje, E. B. (2014). An integrative framework for the analysis of multiple and multimodal representations for meaning-making in science education. *Science Education*, *98*(2), 305–326

Tang, K. (2014). A Literature Review of Science Communication. Tersedia di http://singteach.nie.edu.sg/issue50-research03/. Diunduh pada 15 Agustus 2017

Tang, Tan & Yeo. (2011). Students' Multimodal Construction of the Work–Energy Concept. International Journal of Science Education, 3(13)

Tang, K.-S. (2013b). Instantiation of multimodal semiotic systems in science classroom discourse. Language Sciences, 37, 22–35

Torrance, M., & Galbraith, D. (2006). The Processing Demands Of Writing. Dalam MacArthur, C., Graham, S., & Fitzgerlad, J. (Eds.). (2006). Handbook of Writing Research. New York: Guilford PublicationsMayer, R. E., & Sims, V. K. (1994). For whom is a picture worth a thousand words? Extensions of a dual coding theory of multimedia learning. *Journal of Educational Psychology*, *86*, 389–401

Tuner, Comprehension Reading for Meaning. Dalam Alexander, J (Ed) Teaching Reading. Boston: Scott Foresma Company, 1998

Tytler, R., Prain V., & Peterson S. (2007). Representational Issues in Students Learning About Evaporation. *Research in Science Education*, 37, 313–331.

Tytler, R., Prain, V., Hubber, P., & Waldrip, B. (2013). Constructing representations to learn in science. Rotterdam: Sense

Urquhart, A. H., & Weir, C. J. (1998). Reading in a second language: Process, product,

and practice. London: Longman van den Broek, P. (2001). Comprehension and memory of narrative texts. Dalam M. A. Gernsbacher (Ed.), Handbook of psycholinguistics (pp. 539–588). New York: Academic Press.

Van Labeke, N., & Ainsworth, S. (2001). Applying the DeFT Framework to the Design of Multi-Representational Instructional Simulations. *Artificial Intelligence in Education*, 314–321.

Vanides,J., Yin, Y.,Tomita, M., and Ruiz-Primo, M. A. (2009). Using Concept Maps in the Science Classroom. Tersedia di https://learningcenter.nsta.org/resource/?id=10.2505/4/ss05_028_08_27

Van Dijk. T. A., and W. Kintsch. (1983). Strategies of discourse comprehension. New York: Academic

Vazquez, A.V.,McLoughlin, K., Sabbagh,M., Runkle, A.C., Simon, J.,Coppola, B.P., & Pazicni, S.(2012). Writing-To-Teach: A New Pedagogical Approach To Elicit Explanative Writing from Undergraduate Chemistry Students. *J. Chem. Educ*. 89, 1025−1031

Vitale, M.R & Romance, N.R. (2007). A Knowledge-Based Framework for Unifying Content-Area Reading Comprehension and Reading Comprehension Strategies. Dalam McNamara, D. S. (Ed.) *Reading Comprehension Strategies*. Lawrence Erlbaum Associates, Inc

Waldrip, B., Prain, V., & Carolan, J. (2006). Learning junior secondary science through multi– modal representation. *Electronic Journal of Science Education, 11*(1), 66–105

----- (2010). Using Multi-Modal Representations to Improve Learning in Junior Secondary Science, J. Res Sci Educ, 40, 65-80

Walton. (2006). Three Steps for Better Reading in Science: Before, During, and After. Tersedia di http://www.nsta.org/publications/news/story.aspx?id= 52997. Diakses pada 25 Agustus 2017

Witte, S., & Al, S. E. T. (2013). Writing to Learn by Learning to Write During the School Science Laboratory : Helping Middle and High School Students Develop They Learn Core Ideas. *Wiley Online Library*.

Wong et al. (2011). Learning with multiple representations: an example of a revision lesson in mechanics. *IOP Science*

Wu, H.K., Lin, Y.F., & Hsu, Y.S. (2013). Effects of representation sequences and spatial ability on students' scientific understandings about the mechanism of breathing. *Instructional Science, 41*, 555–573

Wu, H.-K., & Puntambekar, S. (2012). Pedagogical affordances of multiple external representations in scientific processes. Journal of Science Education and Technology, 21(6)

Wu, H.-K., & Shah, P. (2004). Exploring visuospatial thinking in chemistry learning. Science Education, 88, 465–492.

Yang, E.-M., Greenbowe, T. J., & Andre, T. (2004). The effective use of an interactive software program to reduce students' misconceptions about batteries. *Journal of Chemical Education*, 81(4), 587–595.

Yeo, J., & Gilbert, J. K. (2014). Constructing a scientific explanation—A narrative account. *International Journal of Science Education, 36*(11), 1902–1935.

---------- (2017).The Role of Representations in Students' Explanations of Four Phenomena in Physics: Dynamics, Thermal Physics, Electromagnetic Induction and Superposition. Dalam: Treagust, Duit &Fischer (Ed), *Multiple Representations in Physics Education*. Switzerland: Springer

Yore & Shymansky. (1991). Reading in Science: Developing an Operational Conception to Guide Instruction. Journal of Science Teacher Education, 2(2), 29 - 36