

**ENGINEERING DESIGN SKILLS DAN PENGUASAAN KONSEP SISWA
PADA MATERI REKAYASA TANAM MELALUI PEMBELAJARAN
STEM**

Tesis

diajukan untuk memenuhi sebagian syarat memperoleh gelar
Magister Pendidikan Biologi



Disusun oleh:

Hadistia Siti Nuryani

NIM. 1707436

**PROGRAM STUDI
PENDIDIKAN BIOLOGI
SEKOLAH PASCASARJANA
UNIVERSITAS PENDIDIKAN INDONESIA
2020**

ENGINEERING DESIGN SKILLS DAN PENGUASAAN KONSEP SISWA
PADA MATERI REKAYASA TANAM MELALUI PEMBELAJARAN
PEMBELAJARAN STEM

Oleh

Hadistia Siti Nuryani, S.Pd

Universitas Pendidikan Indonesia, 2020

Tesis diajukan untuk memenuhi salah satu syarat memperoleh gelar Magister
Pendidikan (M.Pd.) pada Program Studi Pendidikan Biologi

© Hadistia Siti Nuryani 2020
Universitas Pendidikan Indonesia
Januari 2020

Hak Cipta dilindungi undang-undang.

Tesis ini tidak boleh diperbanyak seluruhnya atau sebagian,
dengan dicetak ulang, difoto kopi, atau cara lainnya tanpa ijin dari penulis.

LEMBAR PENGESAHAN

**ENGINEERING DESIGN SKILLS DAN PENGUASAAN KONSEP SISWA
PADA MATERI REKAYASA TANAM MELALUI PEMBELAJARAN
STEM**

Hadistia Siti Nuryani
1707436

Disetujui Oleh:

Pembimbing I



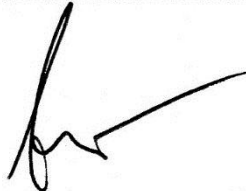
Prof. Dr. Phil. Ari Widodo, M. Ed
NIP. 196705271992031001

Pembimbing II



Dr. Wahyu Surakusumah, M.T
NIP. 197212301999031001

Mengetahui,
Ketua Departemen Pendidikan Biologi
Sekolah Pascasarjana Universitas Pendidikan Indonesia



Dr. Bambang Supriatno, M.Si
NIP. 196305211988031002

Engineering Design Skills dan Penguasaan Konsep Siswa pada Materi Rekayasa Tanam melalui Pembelajaran STEM

Hadistia Siti Nuryani, Ari Widodo, dan Wahyu Surakusumah
Departemen Pendidikan Biologi, FPMIPA, Universitas Pendidikan Indonesia
Hadistia.14@upi.edu

ABSTRAK

Untuk meningkatkan kualitas daya saing di abad 21, negara-negara maju telah menerapkan STEM dalam pembelajaran. STEM merupakan sebuah pendekatan yang mengintegrasikan empat disiplin ilmu science, technology, engineering, dan mathematic dalam sebuah pembelajaran terpadu berdasarkan penerapan pada kehidupan nyata. Tujuan penelitian ini diantaranya adalah menganalisis pencapaian *Engineering design skills* dan penguasaan konsep siswa pada materi rekayasa tanam melalui pembelajaran STEM. Pembelajaran Rekayasa Tanam berbasis STEM untuk meningkatkan *Engineering design skills* dan Penguasaan Konsep Siswa dalam menghasilkan ide, solusi atau desain yang baru untuk dimasa yang akan datang. Penelitian ini menggunakan metode kuantitatif dan desain penelitiannya adalah *quasi experimental nonrandom assignment* dimana sampel penelitian terdiri dari 20 siswa kelas STEM dan 20 siswa kelas non-STEM. Data penelitian dikumpulkan menggunakan task *engineering design skills* untuk mengukur bagaimana pencapaian siswa dalam *engineering design skills* yang dimiliki, dan mengukur sejauh mana penguasaan konsep yang dimiliki siswa dari pembelajaran rekayasa tanam berbasis STEM. Hasil penelitian ini menunjukkan adanya perbedaan pencapaian *engineering design skills* siswa terjadi karena adanya pengaruh atau dampak dari pembelajaran berbasis STEM dalam aktifitas pembelajarannya. Selain itu hasil studi juga menunjukkan adanya pengaruh pembelajaran berbasis STEM terhadap penguasaan konsep siswa. Rata-rata hasil analisis siswa memang nampak ada perbedaan namun perbedaan yang didapat masih termasuk ke dalam kategori rendah. Oleh karena itu, disimpulkan pembelajaran rekayasa tanam berbasis STEM dapat meningkatkan *engineering design skills* dan penguasaan konsep siswa namun harus dilakukan beberapa perbaikan pada aspek-aspek tertentu dan membutuhkan waktu yang panjang.

Kata kunci : Pembelajaran STEM, Engineering Design Skills, Penguasaan Konsep

ENGINEERING DESIGN SKILLS AND MASTERING STUDENT CONCEPT IN PLANT ENGINEERING MATERIALS THROUGH STEM LEARNING

Hadistia Siti Nuryani, Ari Widodo, and Wahyu Surakusumah
Department Education of Biology, FPMIPA Universitas Pendidikan Indonesia
Hadistia.14@upi.edu

ABSTRACT

To improve the quality of competitiveness in the 21st century, developed countries have implemented STEM in learning. STEM is an approach that integrates the four disciplines of science, technology, engineering, and mathematics in an integrated learning based on application in real life. The purpose of this study is to analyze the achievement of Engineering design skills and mastery of students' concepts in planting engineering materials through STEM learning. STEM-based Engineering Learning to improve Engineering design skills and Mastery of Student Concepts in generating new ideas, solutions or designs for the future. This research uses quantitative methods and the research design is a quasi experimental nonrandom assignment where the research sample consists of 20 STEM class students and 20 non-STEM class students. The research data were collected using task engineering design skills to measure how students achieve their engineering design skills, and measure the extent of mastery of the concepts students have from learning STEM-based planting engineering. The results of this study indicate that there are differences in the achievement of engineering design skills of students due to the influence or impact of STEM-based learning in learning activities. In addition, the study results also show the influence of STEM-based learning on the mastery of student concepts. The average analysis result of students does seem to have differences but the differences obtained are still included in the low category. Therefore, it is concluded that STEM-based learning in planting engineering can improve engineering design skills and mastery of students' concepts, but some improvements must be made in certain aspects and require a long time.

Keywords : Concept mastery, Engineering skills, STEM-based learning

DAFTAR PUSTAKA

- Afianti, E. (2017). Penerapan Asesmen Kinerja pada Pembelajaran Berbasis STEM untuk Mengungkap Kreativitas dan Kolaborasi Siswa SMP pada Materi Sistem Organisasi Kehidupan. Universitas Pendidikan Indonesia. Bandung.
- Alacaci, C., & Doğruel, M. (2010). Solving A Stability Problem By Polya's Four Steps. *International Journal Of Electronics, Mechanical And Mechatronics Engineering*. 1(1) 19-28.
- Aljughaiman, A. & Mowrer, R. E. (2005). Teachers' conception of creative and creative students. *Journal of Creative Behavior*, 39(1) 17-34.
- Arlingga, A. (2018). Pembelajaran Berbasis STEM untuk Membangun Kualitas Detail Engineering Design dan Appropriate Technology Product Siswa. Universitas Pendidikan Indonesia, Bandung.
- Asmuniv. (2015). Pendekatan Terpadu Pendidikan STEM dalam Upaya Mempersiapkan Sumber daya Manusia Indonesia yang Memiliki Pengetahuan Interdisipliner untuk Menyongsong Kebutuhan Bidang Karir Pekerjaan Masyarakat Ekonomi ASEAN (MEA). *Widyaswara*, Published on Friday, 15 Mei 2015.
- Asmuniv. (2016). Pendekatan Terpadu Pendidikan STEM Upaya Mempersiapkan Sumber Daya Manusia Indonesia yang Memiliki Pengetahuan Interdisipliner dalam Menyongsong Kebutuhan Bidang Karir Pekerjaan Masyarakat Ekonomi Asean (MEA). [Online]. Diakses dari : <http://www.vedcmalang.com/pppstkboemlg/index.php/menutama/listrik/electro/1507-asv9>.
- Becker, K., & Park, K. (2011). Effects of integrative approaches among science, technology, engineering, and mathematics (STEM) subjects on students' learning: A preliminary meta-analysis. *Journal of STEM Education*, 12(5), 23-38. <https://doi.org/10.1037/a0019454/>
- Beers, S. 2011. 21st Century Skills : Preparing Students For Their Future. Diakses dari http://www.yinghuaacademy.org/wp-content/uploads/2014/10/21st_century_skills.pdf.
- Boesdorfer, S. B., & Livermore, R. A. (2017). Secondary school chemistry teacher's current use of laboratory activities and the impact of expense on their laboratory choices. *Chem. Educ. Res. Pract.*, 1-28.
- Bybee, R. W. (2010). Advancing STEM education: A 2020 vision. *Technology and Engineering Teacher*, 70(1), 30-35.
- Bybee, R. W. (2013). The case for STEM education: Challenges and opportunity. *Arlington, VI: National Science Teachers Association (NSTA) Press*.

- Hanum, C. (2008). Teknik Budidaya Tanaman. Jilid 1. *Direktorat Pembinaan Sekolah Menengah Kejuruan*. Departemen Pendidikan Nasional.
- Christiaans, H., dan Dorst, K. (1992). Cognitive Models in Industrial Design Engineering. *Design Theory and Methodology*, 42 (2), 131-140.
- Crismond, D. P., & Adams, R. S. (2012). The informed design teaching and learning matrix. *Journal of Engineering Education*, 101(4), 738–797.
- Creswell, J. W. (2009). Research Design: Qualitative, Quantitative, and Mixed Methods Approaches. (edisi ketiga). *Thousand Oaks: Sage*.
- Crowder, James A., Carbone, Jhone N., Demijhon, Russell,. (2016). Multidisciplinary system engineering. *English International Journal of STEM Education*, 27-64.
- Cross, N. (2001). Engineering design methods: Strategies for product design(3rde). *Ney Work: John Wiley & Sons*.
- Dahar, R. W. (2003). Teori-teori belajar. Jakarta: Gelora Aksara Prima.
- Damayanthi, E. (2017). Pengaruh Penerapan Pembelajaran Berbasis STEM terhadap Keterampilan Rekayasa dan Sikap Ilmiah Siswa pada Materi Ekosistem. Universitas Pendidikan Indonesia, Bandung.
- Dixon, R. A. (2011). Selected Core Thinking Skills and Cognitive Strategy of an Expert and Novice Engineer. *Journal of sTEm Teacher Education*, 48(1), 36–67. <https://doi.org/10.1017/CBO9781107415324.004>
- Dugger, W. E. (2010). Evolution of STEM in the U. S. Cross, N., Keynes, M., & Uk, M. K. (2002). *Creative Cognition in Design : Processes of Exceptional Designers*. Department of Design and Innovation, The Open University,141.
- Duong, Minh-Quang. (2012). Analytical Evaluation of College Learning Experiences on Student’s Problem Solving Efficacy among Technical and Scientific. *Areas*. (Online), (<http://iaesjournal.com/online/index.php/IJERE/article/view/1663>), diakses 21 Juli 2013.
- Demircioglu, T. (2015). Investigating the Effect of Argument-Driven Inquiry in Laboratory Instruction. *Article in Educational Sciences: Theory and Practice*.
- Dewi, M. (2018). Penerapan Pembelajaran Fisika Menggunakan Pendekatan STEM untuk Meningkatkan Kemampuan Memecahkan Masalah Siswa pada Materi Listrik Dinamis. Universitas Pendidikan Indonesia
- Dorst, K., & Cross, N. (2011). Creativity in the design process: co-evolution of problem solution. *International Journal of Design*, 22(5), 425–437. [https://doi.org/10.1016/s0142-694x\(01\)00009-6](https://doi.org/10.1016/s0142-694x(01)00009-6)

- English, L. D., dan King, D. T. (2015). STEM Learning Trough Engineering Design: Fourth-Grade Students' Investigation in Acrospace. *International Journal of STEM Education*, 2 (4), hlm. 18-23.
- English, L. D. (2016). STEM education K-12: perspectives on integration. *International Journal of STEM Education*, 3(1), 3. <https://doi.org/10.1186/s40594-016-0036-1>
- Fabby, C., & Koenig, K. (2015). Examining the Relationship of Scientific Reasoning with Physics Problem Solving. *Journal of STEM Education: Innovations and Research*, 16(4), 20.
- Firman, H. (2015). Pendidikan Sains Berbasis STEM: Konsep, Pengembangan, dan Peranan Riset Pascasarjana. Bandung: Universitas Pendidikan Indonesia.
- Firman, H., Rustaman, N., dan Suwarma, R. I. (2015). Development Technology and Engineering Literacy through STEM-Based Science Education. Makalah dipresentasikan di “*The 1 st International Conference on Innovation in Engineering and Vocational Education with theme: “Sustainable Development for Engineering & Vocatioal Education”*”. Diselenggarakan di Bandung pada 14 November 2015.
- Fortus, D., Dershimer, R. C., Krajcik, J., Marx, R. W., & Mamlok-Naaman, R. (2004). *Design-based science and student learning*. *Journal of Research in Science Teaching*, 41(10), 1081–1110. <https://doi.org/10.1002/tea.20040>
- Gattie, D. K., & Wicklein, R. C. (2007). Curricular Value and Instructional needs for Infusing Engineering Design into K-12 Technology Education. *Journal of Technology Education*. 19(1), hlm. 6-18.
- Gustiani, I. (2016). Learning Science Through Science, Technology, Engineering and Mathematics (STEM) Based Instructional Material: Its Effectiveness in Improving Students' Conceptual Understanding and Its Effect Towards Engineering Design Behaviors and Teamwork Skills. (Tesis). Sekolah Pascasarjana. Universitas Pendidikan Indonesia, Bandung.
- Hani, R. dan Suwarma, I. R. 2018. Profil Motivasi Belajar IPA Siswa Sekolah Menengah Pertama dalam Pembelajaran Ipa Berbasis STEM. *Jurnal Wahana Pendidikan Fisika*, 3(1): 62-68.
- Hanover Research (2011). *K-12 STEM education overview*.
- Hasanah. U., (2018). Pengaruh Pembelajaran Berbasis STEM terhadap Literasi Teknologi dan Kreativitas Produk Siswa SMA pada Materi Pencemaran Lingkungan. Universitas Pendidikan Indonesia
- Haylock, D. 1997. Recognizing Mathematical Creativity. *Zentralblatt für Didaktik der Mathematik (ZDM) – The International Journal on Mathematics Education*. [Online]. Tersedia: <http://www.emis.de/journals/ZDM/zdm973a5.pdf>. [15 Maret 2007]

- Hsu, H. & Lachenbruch, P. A. (2008). Paired t test. *Wiley Encyclopedia of Clinical Trials*, hlm. 1-3.
- Husna, S., Parlan., dan Sukarianingsih. (2013). Pengaruh Model Pembelajaran Learning Cycle 5-E pada Materi Hidrokarbon terhadap Hasil Belajar Siswa Kelas XI SMKN 2 Batu Program Keahlian Agribisnis Hasil Pertanian. *Jurnal-online.umac.id*. Diakses: 23 Agustus 2016 (21:26).
- Hoeruni, Y. (2017). Pengaruh Pembelajaran IPA Berbasis STEAM terhadap Keterampilan Rekayasa dan Keterampilan Berfikir Kreatif Siswa SMP. Universitas Pendidikan Indonesia, Bandung.
- Honey, M., Pearson, G., dan Schweingruber, A. (2014). STEM Integration in K-12 Education: Status Prospects, and an Agenda for Research. *Washington: national Academies Press*.
- Ismayani. A. 2016. Pengaruh Penerapan STEM Project-Based Learning terhadap Kreativitas Matematis Siswa SMK. *Indonesian Digital Journal of Mathematics and Education Volume 3 Nomor 4 Tahun 2016 hlm. 264-272*.
- Jin. S. H. (2015). A Performance Based Evaluation Rubric for Assessing and Enhancing Engineering Design Skills in Introductory Design Courses. *Article in. International Journal of Engineering Education*.
- Johnson, C. C., Peters, E. E., & J.Moore, T. (2015). STEM Road Map: A Framework for Integrated STEM Education.
- Jonassen, D., Johannes S.,& Chwee B.L. (2006). Everyday Problem Solving in Engineering: Lesson for Engineering Educators. *Journal of Engineering Education 3(17)*, hlm. 139-151.
- Kapila, V. & Iskander, M. (2014). Lessons learned from conducting a K-12 project to revitalize achievement by using instrumentation in Science Education. *Journal of STEM Education*, 15 (1), pp. 46-51.
- KBBI. (2016). *Kamus Besar Bahasa Indonesia*. [Online]. Diakses dari :<http://kbbi.web.id/rekayasa>.
- Khaerunnisa, Nanda Fawzia. (2017). Pengaruh Pembelajaran Berbasis STEM terhadap Keterampilan Desain Produk pada Materi Ekosistem. Universitas Pendidikan Indonesia.
- Kelley, T.R. & Knowles, J. G. (2016). A Conceptual Framework for Integrated STEM Education. *Internation Journal of STEM Education 3(11)*, hlm.1-11.
- Kellgren *et al.* (2016). Innovations and Challenges in Project-Based STEM Education: Lesson from ITEST. *Journal Science Education Technology*, 25 (6), hlm. 825-832.

- Kelley, T.R., & Knowles, J.G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education*, 3 (11).
- Kemdikbud. Lampiran Peraturan Menteri Pendidikan dan Kebudayaan, Pub. L. No. 68 (2013).Indonesia.
- Kemendikbud. Kurikulum 2013. (2013). Indonesia.
- Kim, Chu, and Lim. (2015). Science Curriculum Changes STEM Education in East Asia. *Science Education in East Asia. Springer International Publishing Switzerland 2015*, 1(1), hlm. 149-226.
- Konicek, Moran, R., & Keeley, P. (2015). Teaching for Conceptual Understanding in Science. *USA: NSTA Press*.
- Kolodner, J. L. (2002). Learning by Design™: Iterations of Design Challenges for Better Learning of Science Skills. *Cognitive Studies*, 9(3), 338-350. See discussions, stats, and author profiles for this publication at: <https://www.researchgate.net/publication/309076599>
- Krajcik, J., & Delen, I. (2016). How to Support Learners in Developing Usable and Lasting Knowledge of STEM. *International Journal of Education in Mathematics, Science and Technology*, 5(1), 21.<https://doi.org/10.18404/ijemst.16863>
- Luthfiyani, S. H. (2019). Pengaruh Pembelajaran Biologi Berbasis STEM terhadap Literasi Teknologi dan Keterampilan Pengambilan Keputusan Siswa SMA. *Indonesian Journal of Biology Education*. ISSN 2621-7260 (Online) 2(2): 77-82.
- Lestari, D. (2017). Pengaruh Pembelajaran Berbasis STEM terhadap Keterampilan Rekayasa dan Penguasaan Konsep Siswa pada Materi Pencemaran Udara. Universitas Pendidikan Indonesia. Bandung.
- Mann, E. L., Rebecca L. M, Michele L. S, Daphne D, & So Y. Y. (2011). Integrating Engineering Into K-6 Curriculum: Developing Talent in The STEM Disciplines. *Journal of Advanced Academics* 3(22), hlm. 639-658.
- Mindarwati, R. (2010). Penerapan Asesmen Kinerja pada Pembelajaran Inkuiri Berbasis Laboratorium untuk Meningkatkan Keterampilan Proses Sains dan Penguasaan Konsep Materi Cahaya Siswa SMP. (Tesis SPs UPI Bandung, 2010, Tidak diterbitkan).
- Mukhopadhyay, Rajib.2013.Problem Solving In Science Learning-Some Important Considerations of a Teacher.(Online), (<http://www.iosrjournals.org/iosrjhss/papers/Vol8-issue6/C0862125.pdf>), diakses tanggal 18 November 2013.

- Mertler, C. A. (2001). Designing Scoring Rubrics for your Classroom. *Practical Assesment, Research & Evaluation*, 7(25). Available at: <http://PAREonline.net/getvn.asp?v=7&n=25> Dikses : 31 Juli 2016 (19:20).
- Metzler, C. W. (2001). Evaluation of a comprehensive behavior management program to improve school-wide positive behavior support. *Education and Treatment of Children* Vol 24, No.4, 2001.
- Moore, Tamara J.; Glancy, Aran W.; Tank, Kristina M.; Kersten, Jennifer A.; Smith, Karl A.; and Stohlmann, Micah S. (2014). "A Framework for Quality K-12 Engineering Education: Research and Development". *Journal of Pre-College Engineering Education Research (J-PEER)*: Vol. 4: Iss. 1, Article 2. <https://doi.org/10.7771/2157-9288.1069>
- Morisson, J. (2006). TIES STEM Education Monograph Series: Attributes of STEM Education. *Teaching Institute for Essential Science*.
- Morrison, J. S. (2006). Attributes of STEM Education: The students, The Academy, The Classroom. TIES STEM Education Monograph Series. *Baltimore: Teaching Institute for Excellence in STEM*, hlm. 1-7.
- Nakakura, J., & Prevena, M. (2013). The Hawaii STEM Learning Strategy and Network: STEM for all and all for STEM. [Online]. Diakses dari: Http://standarstoolkit.k12.hi.us/wpcontent/uploads/2013/04stemhelpsallstudentslearn_pdmaterials_181.pdf.
- National Research Council. (2009). Engineering in K-12 education: Understanding the status and improving the prospects. *Washington, DC: The National Academies*.
- National STEM Education Center. (2014). STEM education network manual. *Bangkok: The Institute for the Promotion of Teaching Science and Technology*.
- Nuryani, H. S., Rustaman, N. Y., Rochintaniawati., D (2018). Student conception about the quality of packaged water. *Journal of Physics: Conference Series*. MSCEIS 2018.
- Next Generation Sains Standar. 2013. Volume 1: The Standards—Arranged by Disciplinary Core Ideas and by Topics. *The National Academies Press Washington, D.C*.
- Obama B. Educate to innovae press conference. 2009. Diakses 17 junI 2017. Tersedia pada <https://www.wired.com/2010/09/president-obama-expands-educate-toinnovate/>
- Oktavia, R., (2015). Penerapan Model Pembelajaran Berbasis Proyek dengan Pendekatan Integrasi STEM dalam Meningkatkan Penguasaan Konsep dan Keterampilan Berpikir Kreatif Siswa SMP pada Materi Gelombang Bunyi. S2 thesis, Universitas Pendidikan Indonesia.

- Projen. (2016). Why is detailed design engineering important. Retrieved from <http://www.projen.co.uk/info-centre/why-is-detailed-design-engineeringimportant/> diakses 10 februari 2017.
- Quang, L. X., Hoang, L. H., Dinh Chuan, V., Hoai Nam, N., Anh, N. T., & Nhung, V. T. H. (2015). Integrated Science, Technology, Engineering and Mathematics (STEM) Education through active experience of designing technical Toys in Vietnamese Schools. *Sciencedomain International: British Journal od Education, Society & Behavioural Science*, 11(2), hlm. 1-12.
- Ritz and Fan.(2014). STEM and Technology Education: International State-of-The-Art. *International Journal Technology Des Education. Springer Science+Business Media Dordrecht 2014*, 25 (4), hlm. 429-451.
- Rusmana, A. N. (2017). Implementasi Pembelajaran IPA Biologi Berbasis STEAM dalam Meningkatkan Keterampilan Rekayasa dan Penguasaan Konsep Siswa SMP. Universitas Pendidikan Indonesia, Bandung.
- Rustaman, N. Y., et al. (2003). Strategi Belajar Mengajar Biologi. Jurusan Pendidikan Biologi. FPMIPA. Universitas Pendidikan Indonesia.
- Rustaman, N. Y. (2016). Pemberdayaan Entrepreneurship: Implementasi Teori-U dalam Bioteknologi Praktis Berbasis STEM. *Prosiding Seminar Nasional Sains dan Entrepreneurship III Tahun 2016* “Reorientasi Bioteknologi dan Pembelajarannya Untuk Menyiapkan Generasi Indonesia Emas Berlandaskan Entrepreneurship”.
- Rustaman, N. Y., et al. (2018). STEM based learning to facilitate middle school students’ conceptual change, creativity and collaboration in organization of living system topic. *4th International Seminar of Mathematics, Science and Computer Science Education*.
- Rustaman, dkk (2005). Strategi Belajar Mengajar Biologi. Malang: Penerbit Universitas Negeri Malang.
- Rustaman, N., Firman, H., dan Kardiawarman. (2004). Ringkasan Eksekutif: Analisis PISA Bidang Literasi Sains. *Puspendik*.
- Revee, E. M. (2013). Implementing Science, Technology, Mathematics, and Engineering (STEM) Education in Thailand and in ASEAN. *Bangkok: Institute for the Promotion of Theaching Science ang Technology (IPTS)*.
- Rogers, G. E. (2005). Pre-engineering’s place in technology education and its effect on technological literacy as perceived by technology education teachers. *Journal of STEM Teacher Education*, 42(3), hlm. 2-22.
- Rose, M. A. (2007). Perceptions of technological literacy among science, technology, engineering, and mathematics leaders. *Journal of Technology Education*. 19(1), halm. 35-52.

- Roberts, A. (2012). A justification for STEM education. *Technology and Engineering Teacher*, 74(8), 1-5.
- Sanders, M. E. (2009). Integrative STEM: Primer [in some places titled STEM, STEM Education, STEMmania]. *The Technology Teacher*, 4(20–26).
- Sidawi, M. M. (2009). Teaching science through designing technology. *International Journal of Technology and Design Education*, 19(3), hlm. 269-287.
- Seely, B. E. (1999). The other re-engineering of engineering education, 1900-1965. *Journal of Engineering Education*, 285-294.
- Septiani, A. (2016). Mengungkap Keterampilan Proses Sains, Kecerdasan Naturalis, dan Kecerdasan Logis Matematika melalui Penelapan Asesmen Kinerja pada Pembelajaran Penyiapan Media Tanam dengan pendekatan STEM. Universitas Pendidikan Indonesia.
- Schubert, T.F, Jacobitz, F.G., & Kim, E.M. (2012). Student Perceptions and Learning of the Engineering Design Process: An assessment at the Freshmen Level. *Research Engineering Design* 23(3), hlm 177-190.
- Schnittka, C, & Bell, R. (2011). Engineering design and conceptual change in science: addressing thermal energy and heat transfer in eighth grade. *International Journal of Science Education*, 33(13), 861-867.
- Sternberg, R. J., Elena L., Grigorenko., and Li-fang Zhang. (2008). Styles of Learning and Thinking Matter in Instruction and Assessment. *Association For Psychological Science*.
- Stohlmann, M., Moore, T., & Roehrig, G. (2012). Considerations for teaching integrated STEM education. *Journal of Pre-College Engineering Education Research*, 2(1), 27-34.
- Tsupros, N., Kohler, R., & Hallinen, J. (2009). STEM education: A project to identify the missing components. *Intermediate Unit 1 and Carnegie Mellon, Pennsylvania*.
- Verharen C., Tharakan J., Middendorff G., Castro M., dan Cadoda. (2011). Introducing survival ethics into engineering education and practice. *English International Journal of STEM Education*. 19 (2), 599-623.
- Wulan, A.R. (2008). “Skenario Baru bagi Implementasi Asesmen Kinerja pada Pembelajaran Sains di Indonesia”. *Mimbar Kependidikan*. 32 (3), 4-12.
- White, D. W. (2014). What is STEM education and why is it important?. *Florida Association of Teacher Educators Journal*, 1(14), 1-9
- Williams, J. (2011). STEM Education: Proceed with caution. *Design and Technology Education: An International Journal*, 16(1), 26–35.

- Williams, P. J. (2011). STEM Education: Proceed with caution. *Design and Technology Education: An International Journal*, 16(1).
- Winkel, W.S, (1991). Bimbingan dan Konseling di Sekolah Menengah: PT. Grasindo. Jakarta
- Winkel, W.S, (1996). Psikologi Pengajaran. Jakarta: PT. Gramedia Widiasarana Indonesia.
- Woods, D. R. (1983). Problem Solving and Chemical Engineering, 1981. In J. T. Sears, D. R. Woods, & R. D. Noble (Eds.), Problem Solving (Vol. 79, pp. 11-25). *New York: American Institute of Chemical Engineers.*
- Woolfolk & Nicolish (2004). Educational psychology dof Teacher. Jakarta: Inisiasi Press.
- World Economic Forum. (2015). The Global Competitiveness Report 2015-2016. [Online]. Diakses dari <http://reports.weforum.org/global-competitiveness-report-2015-2016/>

DAFTAR ISI

ABSTRAK	i
DAFTAR ISI.....	
DAFTAR TABEL	vii
DAFTAR GAMBAR.....	viii
DAFTAR LAMPIRAN	ix

BAB I PENDAHULUAN

A. Latar belakang penelitian	1
B. Rumusan masalah penelitian.....	8
C. Tujuan penelitian	8
D. Manfaat penelitian	8
E. Struktur organisasi tesis	9

BAB II KAJIAN PUSTAKA

A. Pembelajaran Sains berbasis STEM	11
B. Engineering Design Skills.....	23
C. Penguasaan Konsep	27
D. Rekayasa Tanam	29
E. Asessment Kinerja	34

BAB III METODE PENELITIAN

A. Desain Penelitian	37
B. Populasi dan Sampel	38
C. Definisi Operasional	39
D. Instrumen penelitian.....	40
E. Prosedur penelitian.....	45
F. Analisis data.....	52
G. Alur penelitian	54

BAB IV TEMUAN DAN PEMBAHASAN

4.1 Ketercapaian Engineering Design Skills Siswa	56
4.1.1 Design Problem (Masalah Desain).....	58

4.1.2 Proses Membuat Rancangan	70
4.1.2.1 Ide Kreatif.....	72
4.1.2.1 Keaslian Ide.....	82
4.1.2.3 Penerapan atau Kebergunaan Ide	89
4.1.3 Proses Akhir	100
4.2 Penguasaan Konsep.....	108

BAB VI SIMPULAN, IMPLIKASI DAN REKOMENDASI

A. Simpulan	123
B. Implikasi	124
C. Rekomendasi.....	125

DAFTAR PUSTAKA	128
-----------------------------	-----

LAMPIRAN	137
-----------------------	-----

DAFTAR TABEL

3.1 Desain Penelitian.....	37
----------------------------	----

3.2 Task Evaluasi Berbasis Kinerja untuk Meningkatkan Engineering Design Skills	41
3.3 Task Pencapaian untuk Menilai dan Meningkatkan Engineering Design Skills	42
3.4 Kisi-kisi Instrumen Post-test	44
3.5 Desain Rekayasa Tanam yang dipilih oleh masing-masing kelompok pada kelas STEM	47
3.6 Matriks Kegiatan Penelitian	48
3.7 Teknik Pengumpulan Data	51
3.8 Perbedaan Kegiatan Pembelajaran di kelas STEM dan non-STEM	51
4.1 Rumusan Masalah yang Dihasilkan Siswa	58
4.2 Hasil Pencapaian Pengenalan Masalah Siswa kelas Eksperimen	60
4.3 Hasil Pencapaian Pengenalan Masalah Siswa kelas Kontrol	64
4.4 Rumusan Ide atau Solusi yang dihasilkan Siswa	71
4.5 Hasil Pencapaian Ide Kreatif Siswa kelas Eksperimen	73
4.6 Hasil Pencapaian Ide Kreatif Siswa kelas Kontrol	76
4.7 Hasil Pencapaian Keaslian Ide Siswa kelas Eksperimen	82
4.8 Hasil Pencapaian Keaslian Ide Siswa kelas Kontrol	86
4.9 Hasil Pencapaian Penerapan atau Kebergunaan Ide Siswa kelas Eksperimen	89
4.10 Hasil Pencapaian Penerapan atau Kebergunaan Ide Siswa kelas Kontrol	94
4.11 Capaian Proses Akhir Siswa kelas Eksperimen	102
4.12 Capaian Proses Akhir Siswa kelas Kontrol	105
4.13 Analisis Statistik Penguasaan Konsep Siswa	108
4.14 Rata-rata Jawaban Siswa	112

DAFTAR GAMBAR

3.1 Alur penelitian	55
---------------------------	----

4.1	Ketercapaian Nilai Engineering Design Skills Siswa.....	56
4.2	Hasil Rata-rata Penguasaan Konsep.....	108

DAFTAR LAMPIRAN

Lampiran 1	137
Lampiran 2	149
Lampiran 3	150
Lampiran 4	160
Lampiran 5	175
Lampiran 6	181
Lampiran 7	185
Lampiran 8	200