PENINGKATAN KETERAMPILAN REKAYASA, MINAT TERHADAP SAINS DAN TEKNOLOGI, KOMUNIKASI ILMIAH SD MELALUI PEMBELAJARAN STEAM BERBASIS TEKNOLOGI

TESIS

diajukan untuk memenuhi salah satu syarat memperoleh

gelar Magister Pendidikan (M.Pd.) pada Program Studi Pendidikan Dasar

oleh

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PROGRAM STUDIPENDIDIKAN DASAR

SEKOLAH PASCASARJANA

UNIVERSITAS PENDIDIKAN INDONESIA

2021

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Universitas Pendidikan Indonesia
Januari, 2021

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Dengan ini saya menyatakan bahwa tesis dengan judul "Peningkatan Keterampilan Rekayasa, Minat terhadap Sains dan Teknologi Komunikasi Ilmiah SD melalui Pembelajaran STEAM Berbasis Teknologi" ini beserta isinya adalah benar-benar karya 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 menanggung risiko/sanksi apabila dikemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

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KATA PENGANTAR

Segala puji dan syukur senantiasa terpanjatkan kepada Allah SWT yang telah melimpah rahmat dan karunia-Nya, shalawat serta salam semoga selalu tercurah kepada Baginda Nabi Muhammad SAW yang telah membawa risalah sebagai penuntun kehidupan umat manusia. Tesis berjudul "Peningkatan Keterampilan Rekayasa, Minat Terhadap Sains dan Teknologi komunikas Ilmiah SD melalui Pembelajaran STEAM berbasis Teknologi" dapat terselesaikan atas ridho-Nya. Penulisan tesis ini bertujuan untuk memenuhi salah satu persyaratan guna memperoleh gelar Magister Pendidikan pada Program Studi Pendidikan Dasar di Universitas Pendidikan Indonesia Bandung. Tesis ini masih kurang dari sempurna untuk itu penuh harapan agar kritik dan saran yang membangun dirasa perlu untuk perbaikan tesis sehingga dapat lebih sempurna. Semoga tesis ini bermanfaat khususnya bagi penulis dan para pembaca.

Bandung, Januari 2021

Penulis

HALAMAN UCAPAN TERIMA KASIH

Penulis ingin mengucapkan terima kasih kepada berbagai pihak yang telah membantu dalam penyusunan tesis ini. Tanpa bantuan dari berbagai pihak tersebut, penulis tidak dapat menyelesaikan tesis ini. Rasa terima kasih yang sangat besar penulis ucapkan kepada:

1. Prof. Dr. Phil. Ari Widodo, M.Ed selaku pembimbing I atas bimbingan, waktu yang selalu diluangkan, kesabaran, masukan, saran serta motivasi yang sering diberikan sangat bermanfaat bagi penulis.
2. Prof. Dr. Andi Suhandi, M.Si. selaku pembimbing II atas waktu yang selalu diluangkan, kesabaran, motivasi, masukan dan saran yang sangat bermanfaat bagi penulis.
3. Prof. Dr Rahman, M.Pd; Irma Rahma Suwarna, Ph.D; Dr.H Atep Sujana, M.Pd; Dr. Ida Kaniawati, M.Si; Dr. Isah Cahyani, M.Pd selaku *Expert Judgment.*
4. Prof. H. Udin Syaefudin Sa'ud dan Dr. H. Atep Sujana, M. Pd. Selaku penguji tesis yang telah memberikan komentar, saran dan masukan untuk perbaikan tesis ini.
5. Al Jupri, S.Pd., M.Sc. Ph.D. yang memberikan arahan dalam perhitungan statistika.
6. Kepala Sekolah SDN NEGLASARI, SDN CIJEROKASO, SDN TEGALEGA dan SD Laboratorium UPI dan guru-guru serta siswa-siswa di Kota Bandung yang telah membantu dalam melakukan penelitian.

Semoga segala bantuan dan kebaikan yang telah diberikan menjadi amal ibadah dan mendapat pahala yang dilipatgandakan oleh Allah SWT. Aamiin

ABSTRAK

PENINGKATAN KETERAMPILAN REKAYASA, MINAT TERHADAP SAINS DAN TEKNOLOGI, KOMUNIKASI ILMIAH SD MELALUI PEMBELAJARAN STEAM BERBASIS TEKNOLOGI

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Pembelajaran STEAM mempunyai banyak manfaat bagi siswa khususnya dalam meningkatkan pembelajaran sains, teknologi, *engineering, art* dan matematika. Selain itu pembelajaran STEAM merupakan pembelajaran abad 21. Pembelajaran STEAM yaitu untuk menyiapkan generasi yang handal dalam bidang IPTEK. Banyak siswa merasa tertarik untuk belajar STEAM hanya saja, pembelajaran STEAM masih dirasa sulit karena siswa Indonesia belum terbiasa dalam pembelajaran STEAM. Penelitian ini bertujuan untuk meningkatkan *engineering skill*, minat sains dan teknologi dan juga melihat kemampuan komunikasi ilmiah siswa SD. Metode penelitian ini menggunakan metode quasi eksperimen desain dan desainnya menggunakan *nonequivalent control group design,* kelompok eksperimen maupun kelompok kontrol tidak dipilih secara random. Sampel diambil dengan teknik *convenient sampling*, yaitu sampel yang diambil seadanya. *Sampel* penelitian ini sebanyak 60 siswa kelas 3 SD di Kota Bandung yaitu di kelas STEAM 30 siswa dan kelas Non STEAM 30 siswa. Hasil penelitian menunjukan bahwa ada peningkatan keterampilan rekayasa pada tahap redesain. Begitupun minat sains dan teknologi di kelas STEAM mengalami peningkatan yang lebih baik dibanding dengan kelas Non STEAM. Selain itu juga komunikasi ilmiah khususnya presentasi oral di kelas STEAM menunjukan hasil yang lebih baik di Bandung dengan kelas Non STEAM. Hasil penelitian ini menunjukan bahwa pembelajaran STEAM dapat meningkatkan keterampilan rekayasa, minat sains dan teknologi dan juga dapat melatih komunikasi ilmiah dalam hal ini presentasi oral.

Kata Kunci : Pembelajaran STEAM, Keterampilan Rekayasa, Minat Sains dan Teknologi, Komunikasi Ilmiah-Presentasi Oral

ABSTRACT

IMPROVEMENT OF ENGINEERING SKILLS, INTEREST IN SCIENCE AND TECHNOLOGY, SCIENTIFIC COMMUNICATION OF ELEMENTARY SCHOOL THROUGH STEAM BASE ON TECHNOLOGY

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1803058

STEAM learning has many benefits for students, especially in enhancing learning science, technology, engineering, arts and mathematics. Then, STEAM learning is the learning of the 21st century. STEAM learning is to prepare a reliable generation in science and technology. Many students were interested in learning STEAM. However, STEAM learning was still difficult because Indonesian students are not used to learning STEAM. This study aims to improve engineering skills, interest in science and technology and also to see the scientific communication skills of elementary school students. This research method used a quasi-experimental design method and the design used the nonequivalent control group design, the experimental group and the control group are not selected randomly. The sample was taken using the convenient sampling technique, that is, the sample was taken as is. The sample of this research was 60 students in grade 3 in Bandung. 30 students in the STEAM Class and 30 students in the Non STEAM Class. The results showed that there was an increase in engineering skills at the redesign stage. Interest in science and technology in the STEAM class has also increased better than in the Non STEAM class. Then, scientific communication especially in the oral presentation in the STEAM class showed better results compared to the Non STEAM class. The results of this study indicate that STEAM learning can improve engineering skills, interest in science and technology and can also train scientific communication on oral presentations.

Keywords: STEAM Learning, Engineering Skills, Interests of Science and Technology, Scientific Communication-Oral Presentations

DAFTAR ISI

DAFTAR TABEL

DAFTAR GAMBAR

DAFTAR LAMPIRAN

DAFTAR PUSTAKA

Abell, S. K., Rogers, M. A. P., Hanuscin, D. L., Lee, M. H., & Gagnon, M. J. (2009). Preparing the Next Generation of Science Teacher Educators: A Model for Developing PCK for Teaching Science Teachers. *Journal of Science Teacher Education*, *20*(1), 77–93. https://doi.org/10.1007/s10972-008-9115-6.

Adriyawati, Utomo, E., Rahmawati, Y., & Mardiah, A. (20AD). Steam-project-based Learning Integration to Improve Elementary School Students' Scientific Literacy on Alternative Energy Learning. *Universal Journal of Educational Research*, *8*(5), 1863–1873. https://doi.org/10.13189/ujer.2020.080523.

Afriana, J., Permanasari, A., & Fitriani, A. (2016). Project based learning integrated to stem to enhance elementary school's students scientific literacy. *Jurnal Pendidikan IPA Indonesia*, *5*(2), 261–267. https://doi.org/10.15294/jpii.v5i2.5493.

Ahn, C. (2015). EcoScience + Art initiative: Designing a New Paradigm for College Education, Scholarship, and Service. *The STEAM Journal*, *2*(1), 1–10. https://doi.org/10.5642/steam.20150201.11.

Ainley, M., & Ainley, J. (2011). A Cultural Perspective on the Structure of Student Interest in Science. *International Journal of Science Education*, *33*(1), 51–71. https://doi.org/10.1080/09500693.2010.518640.

Akpinar, E., Yildiz, E., Tatar, N., & Ergin, Ö. (2009). Students' Attitudes toward Science and Technology: An Investigation of Gender, Grade Level, and Academic Achievement. *Procedia - Social and Behavioral Sciences*, *1*(1), 2804–2808. https://doi.org/10.1016/j.sbspro.2009.01.498.

Alemdar, M., Lingle, J. A., Wind, S. A., & Moore, R. A. (2017). Developing an Engineering Design Process Assessment Using Think-Aloud Interviews. *International Journal of Engineering Education*, *33*(1), 441–452.

Anderson, J. R. (1982). Acquisition of Cognitive Skill. *Psychological Review*, *89*(4), 369–406. https://doi.org/10.1037/0033-295X.89.4.369.

Anisimova, T. I., Sabirova, F. M., & Shatunova, O. V. (2020). Formation of Design and Research Competencies in Future Teachers in the Framework of STEAM Education. *International Journal of Emerging Technologies in Learning*,

15(2), 204–217. https://doi.org/10.3991/ijet.v15i02.11537.

Ann Renninger, K. (2000). Individual Interest and its Implications for Understanding Intrinsic Motivation. *Intrinsic and Extrinsic Motivation*, 373–404. https://doi.org/10.1016/b978-012619070-0/50035-0

Anwari, I., Yamada, S., Unno, M., Saito, T., Suwarma, I. R., Mutakinati, L., & Kumano, Y. (2015). Implementation of Authentic Learning and Assessment through STEM Education Approach to Improve Students' Metacognitive Skills. *K-12 STEM Education, 1*(3), 123–136.

Apriyani, R., Ramalis, T. R., & Suwarma, I. R. (2019). Analyzing Student's Problem Solving Abilities of Direct Current Electricity in STEM-based Learning. *Journal of Science Learning*, *2*(3), 85–91. https://doi.org/10.17509/jsl.v2i3.17559.

Ariani, Y., Helsa, Y., Ahmad, S., & Prahmana, R. C. I. (2018). Edmodo Social Learning Network for Elementary School Mathematics Learning. *Journal of Physics: Conference Series*, *943*(1). https://doi.org/10.1088/1742-6596/943/1/012056.

Astawan, I. G., Sudana, D. N., Kusmariyatni, N., & Japa, I. G. N. (2019). The STEAM Integrated Panca Pramana Model in Learning Elementary School Science in the Industrial Revolution Era 4.0. *International Journal of Innovation, Creativity and Change*, *5*(5), 26–39.

Atman, C. J., Adams, R. S., Cardella, M. E., Turns, J., Mosborg, S., & Saleem, J. (2007). Engineering Design Processes: A Comparison of Students and Expert Practitioners. *Journal of Engineering Education*, *96*(4), 359–379. https://doi.org/10.1002/j.2168-9830.2007.tb00945.x.

Awang, H., & Ramly, I. (2008). Creative Thinking Skill Approach through Problem-Based Learning: Pedagogy and Practice in the Engineering Classroom. *International Journal of Human and Social Sciences*, *3*(1), 18–23. https://doi.org/10.5281/zenodo.1084905.

Badriyah, N. L., Anekawati, A., & Azizah, L. F. (2020). Application of PjBL with Brain-based STEAM Approach to Improve Learning Achievement of Students. *Jurnal Inovasi Pendidikan IPA*, *6*(1), 88–100. https://doi.org/10.21831/jipi.v6i1.29884.

Baines, L. (2015). Emerging Technologies for STEAM Education. *Emerging Technologies for STEAM Education*, 247–258. https://doi.org/10.1007/978-3-319-02573-5.

Banchero, S. B. (2013). *High-School Graduation Rate Inches Up-Percentage of Students in Public Institutions Getting Diplomas Reached 35-Year High in 2010, But Country Still Lags Peers*.

Barrett, T., Anttila, E., Ruthmann, S. A., Haseman, B., & Ghanbari, S. (2015). Learning Across Disciplines: A Collective Case Study Of Two University Programs That Integrate The Arts With STEM. *International Journal of Education & the Arts*, *16*(7), 1–21.

Bequette, J. W., & Bequette, M. B. (2012). A Place for Art and Design Education in the STEM Conversation. *Art Education*, *65*(2), 40–47. https://doi.org/10.1080/00043125.2012.11519167.

Berland, L. K., & Steingut, R. (2016). Explaining Variation in Student Efforts towards Using Math and Science Knowledge in Engineering Contexts. *International Journal of Science Education*, *38*(18), 2742–2761. https://doi.org/10.1080/09500693.2016.1260179.

Bethke Wendell, K., & Rogers, C. (2013). Engineering Design-Based Science, Science Content Performance, and Science Attitudes in Elementary School. *Journal of Engineering Education*, *102*(4), 513–540. https://doi.org/10.1002/jee.20026.

Birt, J., & Cowling, M. (2017). Toward Future "Mixed Reality" Learning Spaces for STEAM Education. *International Journal of Innovation in Science and Mathematics Education*, *25*(4), 1–16.

Bozdoğan, A. E., & Yalçin, N. (2009). Determining the Influence of a Science Exhibition Center Training Program on Elementary Pupils' Interest and Achievement in Science. *Eurasia Journal of Mathematics, Science and Technology Education*, *5*(1), 27–34. https://doi.org/10.12973/ejmste/75254.

Brown, A. S., & Tepper, S. J. (2012). *Placing the Arts at the Heart of the Creative Campus.* Association of Performing Arts Presenters, 1211 Connecticut Avenue, NW, Washington, DC.

Burns, T. W., O'Connor, D. J., & Stocklmayer, S. M. (2003). Science

Communication: A Contemporary Definition. *Public Understanding of Science*, *12*(2), 183–202. https://doi.org/10.1177/09636625030122004.

Bush, S. B., & Cook, K. L. (2019). Structuring STEAM Inquiries: Lessons Learned from Practice. In M. S. Khine & S. Areepattamannil (Eds.), *STEAM Education: Theory and Practice* (pp. 19–20). Cham: Springer.

Bybee, R. W. (2010). What is STEM Education? *Science*, *329*(5995), 996. https://doi.org/10.1126/science.1194998.

Care, E., & Griffin, P. (2015). *Assessment and Teaching of 21 Century Skills*. Springer.

Carson, A. D. (2002). *The Selection Ofinterests*. Retrieved from http://www.vocationalpsychology.com/essay6interest.htm.

Chabalengula, V. M., & Mumba, F. (2017). Engineering Design Skills Coverage in K-12 engineering Program Curriculum Materials in the USA. *International Journal of Science Education*, *39*(16), 2209–2225. https://doi.org/10.1080/09500693.2017.1367862.

Choi, Y., Lim, Y., & Son, D. (2017). A Semantic Network Analysis on the Recognition of STEAM by Middle School Students in South Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *13*(10), 6457–6469. https://doi.org/10.12973/ejmste/77950.

Christensen, R., & Knezek, G. (2015). Emerging Technologies for STEAM Education. *Emerging Technologies for STEAM Education*. https://doi.org/10.1007/978-3-319-02573-5.

Chu, H. E., Martin, S. N., & Park, J. (2019). A Theoretical Framework for Developing an Intercultural STEAM Program for Australian and Korean Students to Enhance Science Teaching and Learning. *International Journal of Science and Mathematics Education*, *17*(7), 1251–1266. https://doi.org/10.1007/s10763-018-9922-y.

Chung, Y., Yoo, J., Kim, S. W., Lee, H., & Zeidler, D. L. (2016). Enhancing Students' Communication Skills in the Science Classroom Through Socioscientific Issues. *International Journal of Science and Mathematics Education*, *14*(1), 1–27. https://doi.org/10.1007/s10763-014-9557-6.

Claire Major. (2001). Assessing The Effectiveness of Problem Based Learning in

Higher Education. *Lessons From The Literature*, *5*(1).

Coffland, D. A., & Xie, Y. (2015). Emerging Technologies for STEAM Education. X. Ge (ed), *Emerging Technologies for STEAM Education* (pp.311–329). https://doi.org/10.1007/978-3-319-02573-5.

Connor, A. M., Karmokar, S., & Whittington, C. (2015). From STEM to STEAM: Strategies for Enhancing Engineering & Technology Education. *International Journal of Engineering Pedagogy (IJEP)*, *5*(2), 37. https://doi.org/10.3991/ijep.v5i2.4458.

Cook, K. L., & Bush, S. B. (2018). Design Thinking in Integrated STEAM learning: Surveying the Landscape and Exploring Exemplars in Elementary Grades. *School Science and Mathematics*, *118*(3–4), 93–103. https://doi.org/10.1111/ssm.12268.

Council, N. R. (2012). *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas*. https://doi.org/10.17226/13165.

Creativity, K. F. for the A. of S. and. (2018). *STEAM Guide for Teachers*. Seoul, South Korea: KOFAC.

Cresswell, J. (2015). *Penelitian Kualitatif dan Desain Riset Memilih Di Antara Lima Pendekatan*. Yogyakarta: Pustaka Pelajar.

Cropley, A. (2010). In Praise of Convergent Thinking. *Creativity Research Journal*, *18*(3), 391–404. https://doi.org/10.1207/s15326934crj1803_13.

Cunningham, C. M. (2016). Engineering Education for Elementary Students. Marc J. de Vries, Lena Gumaelius, Inga-Britt Skogh (Eds.). *Pre-University Engineering Education* (pp.81–99). https://doi.org/10.1007/978-94-6300-621-7_6.

Damayanthy, E. (2017). *Pengaruh Penerapan Pembelajaran Berbasis STEM terhadap Keterampilan Rekayasa dan Sikap Ilmiah Siswa pada Materi Ekosistem*. S1 Thesis, Universitas Pendidikan Indonesia.

Dankenbring, C., & Capobianco, B. M. (2016). Examining Elementary School Students' Mental Models of Sun-Earth Relationships as a Result of Engaging in Engineering Design. *International Journal of Science and Mathematics Education*, *14*(5), 825–845. https://doi.org/10.1007/s10763-015-9626-5.

Davidson, R. J. (2000). Affective Style, Psychopathology, and Resil- ience: Brain Mechanisms and Plasticity. *American Psychologist*, *55*, 1196–1214.

Duckworth, A. L., Peterson, C., Matthews, M. D., & Kelly, D. R. (2007). Grit: Perseverance and Passion for Long-Term Goals. *Journal of Personality and Social Psychology*, *92*(6), 1087–1101. https://doi.org/10.1037/0022-3514.92.6.1087.

Dugger, W. E. (2010). Evolution of STEM in the United States. *6Th Biennial International Conference on Technology Education Research*, 1–8. Retrieved from http://www.iteea.org/Resources/PressRoom/AustraliaPaper.pdf.

Dym, C. L., Agogino, A. M., Eris, O., Frey, D. D., & Leifer, L. J. (2006). Engineering Design Thinking, Teaching, and Learning. *IEEE Engineering Management Review*, *34*(1), 65–90. https://doi.org/10.1109/emr.2006.1679078.

Eccles, J. S. (2005). Influences of Parents' Education on Their Children's Educational Attainments: The Role of Parent and Child Perceptions. *London Review of Education*, *3*(3), 191–204. https://doi.org/10.1080/14748460500372309.

Engelman, S., Magerko, B., McKlin, T., Miller, M., Edwards, D., & Freeman, J. (2017). Creativity in Authentic STEAM Education with Earsketch. *Proceedings of the Conference on Integrating Technology into Computer Science Education, ITiCSE*, 183–188. https://doi.org/10.1145/3017680.3017763.

English, L. D., & King, D. T. (2015). STEM Learning through Engineering Design: Fourth-Grade Students' Investigations in Aerospace. *International Journal of STEM Education*, *2*(1). https://doi.org/10.1186/s40594-015-0027-7.

Enriquez, M. A. S. (2014). Students ' Perceptions on the Effectiveness of the Use of Edmodo as a Supplementary Tool for Learning. *Presented at the DLSU Research Congress*, 6–11.

Estapa, A. T., & Tank, K. M. (2017). Supporting Integrated STEM in the Elementary Classroom: A Professional Development Approach Centered on An Engineering Design Challenge. *International Journal of STEM Education*, *4*(1). https://doi.org/10.1186/s40594-017-0058-3.

F.J Rutherford, B. A. (2005). Science For All Americans, for Science Literacy , Project 2061 , by American Association for the Advancement of Science (AAAS). *Merrit Tuckey Spring*, 1–4.

Fantuzzo, J., & Ginsburg-Block, M. (1998). for Elementary School Students. *Peer-Assisted Learning*, *3*(2), 121.

Firman, H., Rustaman, N. Y., & Suwarma, I. R. (2016). Development Technology and Engineering Literacy Through STEM-Based Education. *(Icieve 2015)*, 209–212. https://doi.org/10.2991/icieve-15.2016.45.

Fraenkel, J. R., Wallen, N. E., & Hyun H. H. (2011). *How to Design and Evaluate Research in Education*. New York: McGrow-Hill Companies

Fulton, L., & Simpson-Steele, J. (2016). Reconciling the Divide: Common Processes in Science and Arts Education. *Steam*, *2*(2), 1–8. https://doi.org/10.5642/steam.20160202.03.

Gates, A. E. (2017). Benefits of a STEAM Collaboration in Newark, New Jersey: Volcano simulation through a glass-making experience. *Journal of Geoscience Education*, *65*(1), 4–11. https://doi.org/10.5408/16-188.1.

Ge, X., Ifenthaler, D., & Spector, J. M. (2015). Emerging Technologies for STEAM Education. *Emerging Technologies for STEAM Education*, 383–395. https://doi.org/10.1007/978-3-319-02573-5.

George, R. (2006). A Cross-Domain Analysis of Change in Students' Attitudes toward Science and attitudes about the Utility of Science. *International Journal of Science Education*, *28*(6), 571–589. https://doi.org/10.1080/09500690500338755.

Graham, N. J., & Brouillette, L. (2017). Using Arts Integration to Make Science Learning Memorable in the Upper Elementary Grades: A Quasi-Experimental Study. *Journal for Learning through the Arts: A Research Journal on Arts Integration in Schools and Communities*, *12*(1). https://doi.org/10.21977/d912133442.

Griffin, P., Care, E., & McGaw, B. (2012). *Assessment and Teaching of 21st Century Skills*. https://doi.org/DOI 10.1007/978-94-007-2324-5.

Gross, M., Latham, D., Underhill, J., & Bak, H. (2016). The Peritext Book Club: Reading to Foster Critical Thinking about STEAM Texts. *School Library*

Research, *19*.

Gu, J., & Belland, B. R. (2015). Emerging Technologies for STEAM Education. *Emerging Technologies for STEAM Education*, 39–60. https://doi.org/10.1007/978-3-319-02573-5.

Gustiani, I., Widodo, A., & Suwarma, I. R. (2017). Development and Validation of Science, Technology, Engineering and Mathematics (STEM) based Instructional Material. *AIP Conference Proceedings*, *1848*(May). https://doi.org/10.1063/1.4983969.

Guyotte, K. W., Sochacka, N. W., Costantino, T. E., & Walther, J. (2014). STEAM as Social Practice: Cultivating Creativity in Transdisciplinary Spaces. *Art Education*, *67*(6), 12–19. https://doi.org/10.1080/00043125.2014.11519293.

Harris, A., & de Bruin, L. R. (2018). Secondary School Creativity, Teacher Practice and STEAM Education: An International Study. *Journal of Educational Change*, *19*(2), 153–179. https://doi.org/10.1007/s10833-017-9311-2.

Hasni, A., & Potvin, P. (2015). Student's Interest in Science and Technology and Its Relationships with Teaching Methods, Family Context and Self-Efficacy. *International Journal of Environmental and Science Education*, *10*(3), 337–366. https://doi.org/10.12973/ijese.2015.249a.

Häussler, P., & Hoffmann, L. (2002). An Intervention Study to Enhance Girls' Interest, Self-concept, and Achievement in Physics Classes. *Journal of Research in Science Teaching*, *39*(9), 870–888. https://doi.org/10.1002/tea.10048.

Henriksen, D. (2014). Full STEAM Ahead: Creativity in Excellent STEM Teaching Practices. *Steam*, *1*(2), 1–9. https://doi.org/10.5642/steam.20140102.15.

Henriksen, D., Mehta, R., & Mehta, S. (2019). Design Thinking Gives STEAM to Teaching: A Framework That Breaks Disciplinary Boundaries. *STEAM Education*, 57–78. https://doi.org/10.1007/978-3-030-04003-1_4.

Herro, D., & Quigley, C. (2016). Innovating with STEAM in Middle School Classrooms: Remixing Education. *On the Horizon*, *24*(3), 190–204. https://doi.org/10.1108/OTH-03-2016-0008.

Herro, D., Quigley, C., Andrews, J., & Delacruz, G. (2017). Co-Measure: Developing An Assessment for Student Collaboration in STEAM Activities.

International Journal of STEM Education, *4*(1). https://doi.org/10.1186/s40594-017-0094-z.

Herro, D., Quigley, C., & Jacques, L. A. (2018). Examining Technology Integration in Middle School STEAM Units. *Technology, Pedagogy and Education*, *27*(4), 485–498. https://doi.org/10.1080/1475939X.2018.1514322.

Hertel, J. D., Cunningham, C. M., & Kelly, G. J. (2017). The Roles of Engineering Notebooks in Shaping Elementary Engineering Student Discourse And Practice. *International Journal of Science Education*, *39*(9), 1194–1217. https://doi.org/10.1080/09500693.2017.1317864.

Hidi, S. (1990). Interest and Its Contribution as a Mental Resource for Learning. *Review of Educational Research*, *60*(4), 549–571. https://doi.org/10.3102/00346543060004549.

Hidi, S. (2001). Interest , Reading , and Learning : Theoretical and Practical Considerations. *Educational Psychology Review*, *13*(3), 191–209.

Hidi, S. (2006). Interest: A Unique Motivational Variable. *Educational Research Review*, *1*(2), 69–82. https://doi.org/10.1016/j.edurev.2006.09.001.

Hidi, S., & Ann Renninger, K. (2006). The Four-Phase Model of Interest Development. *Educational Psychologist*, *41*(2), 111–127. https://doi.org/10.1207/s15326985ep4102_4.

Hidi, S., & Baird, W. (1986). Interestingness-A Neglected Variable in Discourse Processing. *Cognitive Science*, *10*(2), 179–194. https://doi.org/10.1016/S0364-0213(86)80003-9.

Hidi, S., & Harackiewicz, J. M. (2000). Motivating the Academically Unmotivated: A Critical Issue for the 21st Century. *Review of Educational Research*, *70*(2), 151–179. https://doi.org/10.3102/00346543070002151.

Hoeruni, Y. (2017). *Pengaruh Pembelajaran IPA Berbasis STEM terhadap Keterampilan Berpikir Kreatif Siswa SMP*. S1 Thesis, Universitas Pendidikan Indonesia.

Hoffmann, L. (2002). Promoting Girls' Interest and Achievement in Physics Classes for Beginners. *Learning and Instruction*, *12*(4), 447–465. https://doi.org/10.1016/S0959-4752(01)00010-X.

Hullender, R., Hoffman, H., & Cunningham, J. (2016). *STEAM : Creating an*

Environment of Inclusion and Innovation. Farwell Area Schools.

ITEA. (2000). *Standards for technological literacy: Content for the study of technology*. Reston VA: International Technology Education Association.

Jeong, S., & Kim, H. (2015). The Effect of A Climate Change Monitoring Program on Students' Knowledge and Perceptions of STEAM Education in Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *11*(6), 1321–1338. https://doi.org/10.12973/eurasia.2015.1390a.

Jewitt, C. (2012). Technology, Literacy, Learning. In *Technology, Literacy, Learning*. https://doi.org/10.4324/9780203964101.

Jho, H., Hong, O., & Song, J. (2016). An Analysis of STEM/STEAM Teacher Education in Korea with a Case Study of Two Schools from A Community of Practice Perspective. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(7), 1843–1862. https://doi.org/10.12973/eurasia.2016.1538a.

Jian, Z., Hua, X., & Xu, L. (2019). Research on STEAM Courses Multi-Dimensional Learning Activities Design. *Proceedings - International Joint Conference on Information, Media, and Engineering, IJCIME 2019*, 175–181. https://doi.org/10.1109/IJCIME49369.2019.00043.

Johnson, K. E., Alexander, J. M., Spencer, S., Leibham, M. E., & Neitzel, C. (2004). Factors Associated with The Early Emergence of Intense Interests within Conceptual Domains. *Cognitive Development*, *19*(3), 325–343. https://doi.org/10.1016/j.cogdev.2004.03.001.

Johri, A., Olds, B. M., Esmonde, I., Madhavan, K., Roth, W. M., Schwartz, D. L., & Tabak, I. (2011). Situated Engineering Learning: Bridging Engineering Education Research and the Learning Sciences. *Journal of Engineering Education*, *100*(1), 151–185. https://doi.org/10.1002/j.2168-9830.2011.tb00007.x.

Joko, & Septia Wulandari, G. (2018). The Development of Learning Management System Using Edmodo. *IOP Conference Series: Materials Science and Engineering*, *336*(1). https://doi.org/10.1088/1757-899X/336/1/012046.

Juraj Miština. (2015). Teaching Engineering Students to Communicate Effectively. *Journal for Research and Education*, *27*(4), 151–154.

https://doi.org/10.1109/TE.1984.4321689.

Kang, N.-H. (2019). A Review of the Effect of Integrated STEM or STEAM (Science, Technology, Engineering, Arts, and Mathematics) Education in South Korea. *Asia-Pacific Science Education*, *5*(1). https://doi.org/10.1186/s41029-019-0034-y.

Kartini, D., & Widodo, A. (2020). Exploring Elementary Teachers', Students' Beliefs and Readiness toward STEAM Education. *Mimbar Sekolah Dasar*, *7*(1), 54–65. https://doi.org/10.17509/mimbar-sd.v7i1.22453.

Katehi, L., Pearson, G., & Feder, M. (2009). Engineering in K-12 Education: Understanding the Status and Improving the Prospects. In *Engineering in K-12 Education: Understanding the Status and Improving the Prospects*. https://doi.org/10.17226/12635.

Keane, L., & Keane, M. (2016). STEAM by Design. *Design and Technology Education, 21*(1), 61–82.

Kelley, D., & Kelley, T. (2013). *Creative Confidence: Unleashing the Creative Potential Within Us All*. William Collins and Crown Business.

Kelly, G. J., & Licona, P. (2018). Epistemic Practices and Science Education. *History, Philosophy and Science Teaching* (pp139–165). https://doi.org/10.1007/978-3-319-62616-1_5.

Kennedy, J., Lee, E., & Fontecchio, A. (2016). STEAM Approach by Integrating the Arts and STEM through Origami in K-12. *Proceedings - Frontiers in Education Conference, FIE*, *2016-Novem*, 2–6. https://doi.org/10.1109/FIE.2016.7757415.

Kim, B.-H., & Kim, J. (2014). Analysis of Articles Related STEAM Education using Network Text Analysis Method. *Elementary Science Education*, *33*(4), 674–682. https://doi.org/10.15267/keses.2014.33.4.674.

Kim, B. H., & Kim, J. (2016). Development and Validation of Evaluation Indicators for Teaching Competency in STEAM Education in Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *12*(7), 1909–1924. https://doi.org/10.12973/eurasia.2016.1537a.

Kim, D.-H., Ko, D. G., Han, M.-J., & Hong, S.-H. (2014). The Effects of Science Lessons Applying STEAM Education Program on the Creativity and Interest

Levels of Elementary Students. *Journal of The Korean Association For Research In Science Education*, *34*(1), 43–54. https://doi.org/10.14697/jkase.2014.34.1.1.00043.

Kim, M. K., Lee, J. Y., Yang, H., Lee, J., Jang, J. N., & Kim, S. J. (2019). Analysis of Elementary School Teachers' Perceptions of Mathematics-Focused STEAM Education in Korea. *Eurasia Journal of Mathematics, Science and Technology Education*, *15*(9), 1–13. https://doi.org/10.29333/ejmste/108482

Kim, Y., & Park, N. (2012). The effect of STEAM Education on Elementary School Student's Creativity Improvement. *Communications in Computer and Information Science*, *339 CCIS*, 115–121. https://doi.org/10.1007/978-3-642-35264-5_16.

King, E. (2004). A Wee Lesson in Science Communication. *PLoS Biology*, *2*(4), 439–440. https://doi.org/10.1371/journal.pbio.0020122.

Krapp, A. (1999). Interest, Motivation and Learning: An Educational-Psychological Perspective. *European Journal of Psychology of Education*, *14*(1), 23–40. https://doi.org/10.1007/BF03173109.

Krapp, A. (2007). An Educational-Psychological Conceptualisation of Interest. *International Journal for Educational and Vocational Guidance*, *7*(1), 5–21. https://doi.org/10.1007/s10775-007-9113-9.

Krapp, A., & Prenzel, M. (2011). Research on Interest in Science: Theories, Methods, and Findings. *International Journal of Science Education*, *33*(1), 27–50. https://doi.org/10.1080/09500693.2010.518645.

Kustijono, S. D. N. (2019). Keefektifan Model Pembelajaran STEM guna Peningkatan Keterampilan Berpikir Kritis Siswa. *Seminar Nasional Fisika (Snf) 2019*, 66–71.

Lachapelle, C. P., & Cunningham, C. M. (2014). *Engineering in Elementary Engineering*. in Engineering in Pre-Collage Settings, 61-88.

Lee, J. W., Park, H. J., & Kim, J. B. (2013). Primary Teachers' Perception Analysis on Development and Application of STEAM Education Program. 초등과학교육, *32*(1), 47–59. https://doi.org/10.15267/keses.2013.32.1.047.

Lestari, D. (2017). *Pengaruh Pembelajaran STEM terhadap Keterampilan*

Rekayasa dan Penguasaan Konsep Siswa pada Materi Pencemaran Udara. S1 Thesis, Universitas Pendidikan Indonesia.

Lewis, A. L. (2015). Emerging Technologies for STEAM Education. Xun GeDirk, IfenthalerJ., & Michael Spector (Eds.). *Emerging Technologies for STEAM Education*. https://doi.org/10.1007/978-3-319-02573-5.

Li, W., Li, G., Mo, W., & Li, J. (2018). *The Influence of STEAM Education on the Improvment of Studentsr Creative Thinking*. *232*(Icadce), 924–927. https://doi.org/10.2991/icadce-18.2018.200.

Liliawati, W., Rusnayati, H., Purwanto, & Aristantia, G. (2018). Implementation of STEAM Education to Improve Mastery Concept. *IOP Conference Series: Materials Science and Engineering*, *288*(1). https://doi.org/10.1088/1757-899X/288/1/012148.

Lindeman;Jabot; Berkley. (2013). *Learning Across the Early Childhood Curriculum*. 3. https://doi.org/10.1108/s0270-4021(2013)0000017018.

Lipstein, R. L., & Renninger, K. A. (2007). Interest for Writing: How Teachers Can Make a Difference. *English Journal*, *96*(4), 79. https://doi.org/10.2307/30047170.

Liu, H., Ludu, M., & Holton, D. (2015). Emerging Technologies for STEAM Education. *Emerging Technologies for STEAM Education*, 331–353. https://doi.org/10.1007/978-3-319-02573-5.

Maeda, J. (2013). STEM + Art = STEAM. *Steam*, *1*(1), 1–3. https://doi.org/10.5642/steam.201301.34.

Malele, V., & Ramaboka, M. E. (2020). The Design Thinking Approach to students STEAM projects. *Procedia CIRP*, *91*(i), 230–236. https://doi.org/10.1016/j.procir.2020.03.100.

Malone, K. L., Tiarani, V., Irving, K. E., Kajfez, R., Lin, H., Giasi, T., & Edmiston, B. W. (2018). Engineering Design Challenges in Early Childhood Education: Effects on Student Cognition and Interest. *European Journal of STEM Education*, *3*(3). https://doi.org/10.20897/ejsteme/3871.

Marmon, M. (2019). STEAM Education. *STEAM Education*, 101–115. https://doi.org/10.1007/978-3-030-04003-1.

Martinez, J. E. (2017). The Search for Method in STEAM Education. *The Search*

for Method in STEAM Education, 21–33. https://doi.org/10.1007/978-3-319-55822-6.

Mehta, R., Keenan, S., Henriksen, D., & Mishra, P. (2019). Developing a Rhetoric of Aesthetics: The (Often) Forgotten Link Between Art and STEM. In *STEAM Education*. https://doi.org/10.1007/978-3-030-04003-1.

Menéndez, A. F., & Min, H. (2019). Promoting Language and STEAM as Human Rights in Education. In *Promoting Language and STEAM as Human Rights in Education*. https://doi.org/10.1007/978-981-13-2880-0.

Milto, E., Wendell, K., Watkins, J., Hammer, D., Spencer, K., Portsmore, M., & Rogers, C. (2016). *Elementary School Engineering for Fictional Clients in Children's Literature*. 263–291. https://doi.org/10.1007/978-3-319-16399-4_11.

Murphy, P. K., & Alexander, P. A. (2000). A Motivated Exploration of Motivation Terminology. *Contemporary Educational Psychology*, *25*(1), 3–53. https://doi.org/10.1006/ceps.1999.1019.

Mustari, R. F., Widodo, A., & Purwianingsih, W. (2018). Perception of Teachers and Agriculture Vocational High School Students on STEM-based Biology Learning. *International Conference on Mathematics and Science Education*, *3*, 486–491.

Mustofa, R. F., & Hidayah, Y. R. (2020). The Effect of Problem-Based Learning on Lateral Thinking Skills. *International Journal of Instruction*, *13*(1), 463–474. https://doi.org/10.29333/iji.2020.13130a

Nahar, A. M. (2017). *The Implementation of E-Learning Synergism Based on Edmodo and Class Discussion as a Solution to Reduce The Mental Crisis*. *1*, 62–65.

National Academy of Engineering and the National Research Council. (2014). STEM Integration in K-12 Education: Status, prospects, and an agenda for Research. Washington, DC: The National Academies Press.

Nicholes, J. (2018). Developing STEM Interest and Genre Knowledge Through Science Fiction Prototyping. *Steam*, *3*(2), 1–13. https://doi.org/10.5642/steam.20180302.14.

Nuryani, H. S. (2020). *Engineering Design Skills dan Penguasaan Konsep Siswa*

pada Materi Rekayasa Tanam melalui Pembelajaran STEM. S2 Thesis, Universitas Pendidikan Indonesia.

Oecd. (2001). *Program for International Student Assessment: Knowledge and Skills for Life First Results from PISA 2000*. 325. Retrieved from http://books.google.com.br/books?id=lWfJ6exf7dwC.

Okumura, S. (2017). Edmodo as a tool for the global connection between Japanese and American college students in language learning. *Research Bulletin of Education, 12*, 9-17.

Oner, A., Nite, S., Capraro, R., & Capraro, M. (2016). From STEM to STEAM: Students' Beliefs about the Use of Their Creativity. *Steam*, *2*(2), 1–14. https://doi.org/10.5642/steam.20160202.06

Ozkan, G., & Umdu Topsakal, U. (2020). Investigating the Effectiveness of STEAM Education on Students' Conceptual Understanding of Force and Energy Topics. *Research in Science and Technological Education*, *00*(00), 1–20. https://doi.org/10.1080/02635143.2020.1769586.

Panksepp, J. (2003). At the Interface of the Affective, Behavioral, and Cognitive Neurosciences: Decoding the Emotional Feelings of the Brain. *Brain and Cognition*, *52*(1), 4–14. https://doi.org/10.1016/S0278-2626(03)00003-4.

Partnership for 21st Century Skills. (2011). P21 Common Core toolkit: A guide to aligning the Common Core State Standards with the Framework for 21st Century Skills. *Framework*. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:P21+Common+Core+Toolkit:+A+Guide+to+Aligning+the+Common+Core+State+Standards+with+the+Framework+for+21st+Century+Skills#0%5Cnhttp://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:P21+Co.

Pell, T., & Jarvis, T. (2001). Developing Attitude to Science Scales for Use with Children of Ages from Five to Eleven Years. *International Journal of Science Education*, *23*(8), 847–862. https://doi.org/10.1080/09500690010016111.

Perignat, E., & Katz-Buonincontro, J. (2019). STEAM in Practice and Research: An Integrative Literature Review. *Thinking Skills and Creativity*, *31*, 31–43. https://doi.org/10.1016/j.tsc.2018.10.002.

Peter. T. (2015). *Transformative Steam Education for the 21 St Century*. (978),

9871834.

Petroski, H. (2003). Engineering: Early Education. *American Scientist*, *91*, 206–209.

Psycharis, S. (2018). Steam in Education: a Literature Review on the Role of Computational Thinking, Engineering Epistemology and Computational Science. Computational Steam Pedagogy (CSP). *S. Psycharis Scientific Culture*, *4*(2), 51–72. https://doi.org/10.5281/zenodo.1214565.

Purbasari, I., Ismaya, E. A., & Suryani, N. (2019). Media Pembelajaran Ilmu Pengetahuan Sosial Berbasis Aplikasi Mobile Learning bagi Siswa Sekolah Dasar. *Jurnal Sejarah, Budaya, dan Pengajarannya*. (2015), 97–106. https://doi.org/10.17977/um020v13i12019p97.

Purcell, A. T., & Gero, J. S. (1998). Drawings and the Design Process. *Design Studies*, *19*(4), 389–430. https://doi.org/10.1016/s0142-694x(98)00015-5.

Quigley, C. F., & Herro, D. (2016). "Finding the Joy in the Unknown": Implementation of STEAM Teaching Practices in Middle School Science and Math Classrooms. *Journal of Science Education and Technology*. https://doi.org/10.1007/s10956-016-9602-z.

Quigley, C. F., Herro, D., & Baker, A. (2019). Moving toward Transdisciplinary Instruction: A Longitudinal Examination of STEAM Teaching Practices. *STEAM Education*, 143–164. https://doi.org/10.1007/978-3-030-04003-1_8.

Renninger, K. A. (2007). Interest and motivation in informal science learning. *Learning*, 1-45.

Renninger, K. A., & Hidi, S. (2002). Student Interest and Achievement: Developmental Issues Raised by A Case Study. *Development of Achievement Motivation.*, 173–195.

Renninger, K. A., & Wozniak, R. H. (1985). Effect of Interest on Attentional Shift, Recognition, and Recall in Young Children. *Developmental Psychology*, *21*(4), 624–632. https://doi.org/10.1037/0012-1649.21.4.624.

Riley, S. (2012). *Use Arts Integration to Enhance Common Core*. Retrieved from https://www.edutopia.org/blog/core-practices-arts-integration-susan-riley.

Riley, S. (2018). *What is STEAM Education?* Retrieved from https://app.monstercampaigns.com/c/ketbgzmf7npuxznlwzf2/.

Robert D. Atkinson, M. M. (2010). *Refueling the U . S . Innovation Economy : Fresh Approaches to STEM Education*.

Rodgers, P. A., Green, G., & McGown, A. (2000). Using Concept Sketches to Track Design Progress. *Design Studies*, *21*(5), 451–464. https://doi.org/10.1016/S0142-694X(00)00018-1.

Rogers, C., & Portsmore, M. (2004). Bringing Engineering to Elementary School. *Journal of STEM Education*, *5*(3), 17–28.

Rosen-O'Leary, R., & Thompson, E. G. (2019). STEM to STEAM: Effect of Visual Art Integration on Long-Term Retention of Science Content. *Journal for Leadership and Instruction*, *18*, 32–35.

Rukoyah, S. O. (2020). *Pembelajaran Berbasis STEM untuk Membangun Keterampilan Rekayasa dan Kemampuan Engineering Productivity Siswa*. S2 Thesis, Universitas Pendidikan Indonesia.

Rush, L. D. (2010). Integrated STEM Education through Project-Based Learning. In *STEM Solutions Manager at Learning.com*. Retrieved from http://www.learning.com.

Rusmana, A. N. (2017). *Implementasi Pembelajaran IPA Biologi Berbasis STEM dalam Meningkatkan Keterampilan Rekayasa dan Penguasaan Konsep Siswa SMP*. S1 Thesis, Universitas Pendidikan Indonesia.

Rustaman, N. Y. (2016). Pemberdayaan Entrepreneurship : Implementasi Teori-U dalam Bioteknologi Praktis Berbasis STEM. *Seminar Nasional Sains Dan Entrepreneurship III Tahun 2016 "Reorientasi Bioteknologi Dan Pembelajarannya Untuk Menyiapkan Generasi Indonesia Emas Berlandaskan Entrepreneurship,"* 1–14.

Ryu, J., Lee, Y., Kim, Y., Goundar, P., Lee, J., & Jung, J. Y. (2020). STEAM in Gifted Education in Korea. In S. R. Smith (Ed.), *Handbook ofGiftedness and Talent Development in the Asia-Pacific* (pp. 1–22). https://doi.org/10.1007/978-981-13-3021-6_35-1.

Sadoski, M. (2001). Resolving the Effects of Concreteness on Interest, Comprehension, and Learning Important Ideas from Text. *Educational Psychology Review*, *13*(3), 263–281. https://doi.org/10.1023/A:1016675822931.

Sanders, M. (2009). STEM, STEM Education, STEM mania. *The Technology Teacher*, *20*, 20–27.

Sandoval, W. A., Greene, J. A., & Bråten, I. (2016). Understanding and Promoting Thinking About Knowledge: Origins, Issues, and Future Directions of Research on Epistemic Cognition. *Review of Research in Education*, *40*(1), 457–496. https://doi.org/10.3102/0091732X16669319.

Saptarani, D., Widodo, A., & Purwianingsih, W. (2019). Biology Teachers and High School Students Perceptions about STEM learning. *Journal of Physics: Conference Series*, *1157*(4), 0–6. https://doi.org/10.1088/1742-6596/1157/4/042007.

Scherz, Z., Spektor-Levy, O., & Eylon, B. S. (2005). "Scientific Communication": An Instructional Program for High-Order Learning Skills and Its Impact on Students' Performance. *Research and the Quality of Science Education*, 231–243. https://doi.org/10.1007/1-4020-3673-6_19.

Schiefele, U. (1996). Topic Interest, Text Representation, and Quality of Experience. *Contemporary Educational Psychology*, *21*(1), 3–18. https://doi.org/10.1006/ceps.1996.0002.

Schraw, G., & Dennison, R. S. (1994). The Effect of Reader Purpose on Interest and Recall. *Journal of Literacy Research*, *26*(1), 1–18. https://doi.org/10.1080/10862969409547834.

Schütze, M., Sachse, P., & Römer, A. (2003). Support Value of Sketching in the Design Process. *Research in Engineering Design*, *14*(2), 89–97. https://doi.org/10.1007/s00163-002-0028-7.

Sen, A., Mai, T., Kastberg, D., Cummings, L., & Perkins, R. (2019). Highlights of U.S. PISA 2018 Results Web Report. *National Center for Educational Statistics*, 1–64.

Sengupta, P., Kim, B., & Shanahan, M.-C. (2019). *Playfully Coding Science: Views from Preservice Science Teacher Education*. https://doi.org/10.1007/978-3-030-29489-2_10.

Shirey, K. L. (2017). Teacher Productive Resources for Engineering Design Integration in High School Physics Instruction (Fundamental). *ASEE Annual Conference and Exposition, Conference Proceedings*, *2017-June*.

https://doi.org/10.18260/1-2--28908.

Smith, O. (2015). Emerging Technologies for STEAM Education. *Emerging Technologies for STEAM Education*, 81–92. https://doi.org/10.1007/978-3-319-02573-5.

Hoeruni, Y. *(2017) Pengaruh Pembelajaran Ipa Berbasis Steam Terhadap Keterampilan Rekayasa Dan Keterampilan Berfikir Kreatif Siswa SMP* Universitas Pendidikan Indonesia| repository.upi.edu | perpustakaan.upi.edu.

Sochacka, N. W., Guyotte, K. W., & Walther, J. (2016). Learning Together: A Collaborative Autoethnographic Exploration of STEAM (STEM + the Arts) Education. *Journal of Engineering Education*, *105*(1), 15–42. https://doi.org/10.1002/jee.20112.

Song, S., & Agogino, A. M. (2004). Insights on Designers' Sketching Activities in New Product Design Teams. *Proceedings of the ASME Design Engineering Technical Conference*, *3*, 351–360. https://doi.org/10.1115/detc2004-57474.

Soroko, N. V., Mykhailenko, L. A., Rokoman, O. G., & Zaselskiy, V. I. (2020). Educational Electronic Platforms for STEAM-Oriented Learning Environment at General Education School. *CEUR Workshop Proceedings*, *2643*, 462–473.

Spector, J. M. (2015). Emerging Technologies for STEAM Education. *Emerging Technologies for STEAM Education*, 3–14. https://doi.org/10.1007/978-3-319-02573-5.

Spektor-Levy, O., Eylon, B. S., & Scherz, Z. (2009). Teaching Scientific Communication Skills in Science Studies: Does it Make A Difference? *International Journal of Science and Mathematics Education*, *7*(5), 875–903. https://doi.org/10.1007/s10763-009-9150-6.

Stocklmayer, S. M. (2001). The Background to Effective Science Communication by the Public. In S. M. Stocklmayer, M. M. Gore, & C. Bryant (Eds.), *Science Communication in Theory and Practice*. Australian National University, Canberra, Australia: Springer-science+Business Media, B.V.

Stroud, A., & Baines, L. (2019). Inquiry, Investigative Processes, Art, and Writing in STEAM. *STEAM Education*, 1–18. https://doi.org/10.1007/978-3-030-04003-1_1.

Su, J. M., Liao, C. T., Chen, C. T., & Wang, L. H. (2019). A Scheme of STEAM Interactive Learning Toy for Musical and Computational Thinking. *Proceedings - International Joint Conference on Information, Media, and Engineering, IJCIME 2019*, (3), 116–118. https://doi.org/10.1109/IJCIME49369.2019.00032.

Taljaard, J. (2016a). A Review of Multi-Sensory Technologies in a Science, Technology, Engineering, Arts and Mathematics (STEAM) Classroom. *Journal of Learning Design*, *9*(2), 46. https://doi.org/10.5204/jld.v9i2.274.

Taljaard, J. (2016b). A Review of Multi-sensory Technologies in a Science, Technology, Engineering, Arts and Mathematics (STEAM) Classroom Defining Learning Styles Background on Multi-Sensory Instruction. *Journal of Learning Design*, *9*(2), 46–55.

Taylor, C. P. (2016). Why is a STEAM Curriculum Perspective Crucial to the 21st Century ? *14th Annual Conference of the Australian Council for Educational Research*, 89–93.

Thurley, C. (2016). Infusing the Arts into Science and the Sciences into the Arts: An Argument for Interdisciplinary STEAM in Higher Education Pathways. *Steam*, *2*(2), 1–8. https://doi.org/10.5642/steam.20160202.18.

Tippett, C. D. (2016). *Teaching Engineering Design in Elementary Science Methods Classes*. *44*, 293–316. https://doi.org/10.1007/978-3-319-16399-4_12

Top, N., & Sahin, A. (2015). Make it Happen: A Study of a Novel Teaching Style, STEM Students on The Stage (SOS)TM, for Increasing Students' STEM Knowledge and Interest Science. In A. Sahin (Ed.), *A Practice-based Model of STEM Teaching, STEM Students on The Stage (SOS)TM*. Rotterdam, Boston, Taipei: Sense Publishers.

Travis, C., & Approaches, T. (2019). The STEAM Revolution. In *The STEAM Revolution*. https://doi.org/10.1007/978-3-319-89818-6

Trivena, T., Widodo, A., Sopandi, W., Budiarti, T., & Gumala, Y. (2018). Fifth-grade elementary school perception of STEM. *International Conference on Mathematics and Science Education of Universitas …*, *3*, 475–480.

Tsurusaki, B. K., Tzou, C., Conner, L. D. C., & Guthrie, M. (2017). 5 5th - 7th

Grade Girls' Conceptions of Creativity: Implications for STEAM Education. *Creative Education*, *8*(2), 255–271. https://doi.org/10.4236/ce.2017.82020.

Ullman, D. G., Wood, S., & Craig, D. (1990). The Importance of Drawing in the Mechanical Design Process. *Computers and Graphics*, *14*(2), 263–274. https://doi.org/10.1016/0097-8493(90)90037-X.

Utari, S., Prima, E. C., Suwarma, I. R., & Suhandi, A. (2020). Engineering Course Model on STEM Education for Middle School Curriculum Setting in Indonesia. *Pervasive Health: Pervasive Computing Technologies for Healthcare*, *1*(August 2020), 1388–1392. https://doi.org/10.4108/eai.12-10-2019.2296386.

Van Der Lugt, R. (2005). How Sketching can Affect the Idea Generation Process in Design Group Meetings. *Design Studies*, *26*(2), 101–112. https://doi.org/10.1016/j.destud.2004.08.003.

Walczak, M. M., & Walczak, D. E. (2009). Do Student Attitudes toward Science Change during a General Education Chemistry Course ? *Journal of Chemical Education*, *86*(8), 985–991.

Watson, A. D., & Watson, G. H. (2013). Transitioning STEM to STEAM: Reformation of engineering education. *Journal for Quality and Participation*, *36*(3), 1–5.

Weinburgh, M. (2000). *Gender, Ethnicity and Grade Level as Predictors of Middle School Students' Attitudes toward Science*. 12. Retrieved from http://eric.ed.gov/?id=ED442662.

Wijaya, A. D., Dina, K., & Amalia. (2015). Implementasi Pembelajaran Berbasis STEAM (Science, Technology, Engineering, Art, and Mathematics) Pada Kurikulum Indonesia. *Seminar Nasional Fisika Dan Aplikasinya*, (November), 85–88.

Wulan, R. A. (2018). *Menggunakan Assemen Kinerja untuk Pembelajaran Sains dan Penelitian* (Cetakan Pe; N. Y. Rustaman, Ed.). UPI Press Bandung.

Wynn, T., & Harris, J. (2012). Toward A Stem + Arts Curriculum: Creating the Teacher Team. *Art Education*, *65*(5), 42–47. https://doi.org/10.1080/00043125.2012.11519191.

Yakman, G. (2006). ST∑@M Education: an overview of creating a model of

integrative education. *Pupils Attitudes Towards Technology 2006 Annual Proceedings. Netherlands.*

Yakman, Georgette, & Lee, H. (2012). Exploring the Exemplary STEAM Education in the U.S. as a Practical Educational Framework for Korea. *Journal of The Korean Association For Science Education*, *32*(6), 1072–1086. https://doi.org/10.14697/jkase.2012.32.6.1072.

Yang, M. C. (2009). Observations on Concept Generation and Sketching in Engineering Design. *Research in Engineering Design*, *20*(1), 1–11. https://doi.org/10.1007/s00163-008-0055-0.

Yoon, M. B., & Baek, J. E. (2018). Development and Application of the STEAM Education Program based on the Soccer Robot for Elementary Students. *International Journal of Mobile and Blended Learning*, *10*(3), 11–22. https://doi.org/10.4018/IJMBL.2018070102.