

**ANALISIS KOMPETENSI *TECHNICAL* BIDANG KEAHLIAN
MANUFAKTUR *AUTOMOTIVE* DALAM KONTEKS INDUSTRI 4.0**

diajukan untuk memenuhi sebagian syarat untuk memperoleh gelar Magister
Pendidikan Teknologi dan Kejuruan Konsentrasi Pendidikan Teknik Mesin



oleh
Jumhan Munif
NIM 2002381

**PROGRAM STUDI PENDIDIKAN TEKNOLOGI DAN KEJURUAN
SEKOLAH PASCASARJANA
UNIVERSITAS PENDIDIKAN INDONESIA**

2022

HALAMAN PERNYATAAN HAK CIPTA

Dengan ini saya menyatakan bahwa tesis dengan judul Analisis Kompetensi Technical Bidang Keahlian Manufaktur Automotive Dalam Konteks Industri 4.0 ini 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 risiko/sanksi apabila dikemudian hari ditemukan adanya pelanggaran etika keilmuan atau ada klaim dari pihak lain terhadap keaslian karya saya ini.

Yang membuat pernyataan,

Jumhan Munif

LEMBAR PENGESAHAN

JUMHAN MUNIF

**ANALISIS KOMPETENSI *TECHNICAL* BIDANG KEAHLIAN
MANUFAKTUR *AUTOMOTIVE* DALAM KONTEKS INDUSTRI 4.0**

disetujui dan disahkan oleh pembimbing:

Pembimbing,



Prof. Dr. Ade Gafar Abdullah, M.Si.
NIP. 197211131999031001

Mengetahui,
Ketua Program Studi Pendidikan Teknologi dan Kejuruan,



Prof. Dr. Ade Gafar Abdullah, M.Si.
NIP. 197211131999031001

Analisis Kompetensi *Technical* Bidang Keahlian Manufaktur *Automotive* dalam Konteks Industri 4.0

Jumhan Munif
2002381

ABSTRAK

Penelitian ini bertujuan untuk mengkaji literatur dan menganalisis pandangan/persepsi responden dari industri mengenai kompetensi yang dibutuhkan di bidang manufaktur *automotive* dalam kerangka industri 4.0. Dalam beberapa tahun terakhir di seluruh dunia, pembuat kebijakan prihatin tentang kompetensi lulusan pendidikan kejuruan dalam hal kebutuhan pasar kerja industri manufaktur *automotive* karena kebutuhan pasar dengan kompetensi yang dimiliki oleh lulusan belum sepenuhnya sinkron. Kompetensi *technical* yang sinkron dengan kebutuhan pasar tenaga kerja industri *automotive* sebenarnya dapat membantu seseorang memperoleh keuntungan, sementara jika perusahaan tidak mendapatkan pekerja yang kompeten sesuai kebutuhan maka akan menghambat proses produksi dan keuntungan perusahaan. Kajian literatur dan wawancara terhadap praktisi industri digunakan sebagai alat dalam pengumpulan data. Berdasarkan data yang sudah terhimpun, baik yang berasal dari kajian literatur dan wawancara terkait kompetensi *technical* yang dibutuhkan di bidang manufaktur *automotive* dalam kerangka industri 4.0 kemudian dari kedua data tersebut dilakukan triangulasi agar mengurangi bias. Kompetensi yang dibutuhkan dalam konteks industri 4.0 berdasarkan kajian literatur yaitu penguasaan *state-of-the-art knowledge*, *technical skill*, *media skill*, *coding skill*, *understanding IT security*. Hasil wawancara dengan praktisi industri manufaktur *automotive* sinkron dengan kajian literatur, namun ada sedikit tambahan kompetensi yaitu *process understanding*. Kebutuhan kompetensi *technical* untuk kedua data hampir sama, namun ada tambahan kompetensi yang disampaikan oleh praktisi industri, yaitu penguasaan teknologi baru atau *state-of-the-art knowledge* dibutuhkan di setiap bidang pekerjaan, dan pada bidang pekerjaan *data analyst* menambahkan satu kompetensi yaitu *process understanding*.

Kata kunci: Kompetensi *technical*, manufaktur *automotive*, industri 4.0, *skill*

*The Analysis of Technical Competency Towards the Automotive
Manufacturing Expertise in The Industrial Context 4.0*

Jumhan Munif
2002381

ABSTRACT

This research aims to study the literature and analyze the point of view/perception from industry about the competencies needed in manufacturing automotive sector within the framework of industry 4.0. In last few years around the world, policy makers are concerned about the competence of vocational education towards the needs of manufacturing automotive industrial labor market because it not fully synced with the competencies that graduates possess. Skill competencies that are in sync with the needs of the automotive industry's labor market can actually help somebody to gain advantage; meanwhile incompetent laborers will hinder the production process and company's benefits. Literature review and interview towards industrial practitioner are used as the tool for data collection. Based on data that has been collected both from literature review and interview related to what technical competencies are needed in the automotive manufacturing sector within the framework of industry 4.0. The both of the data are triangulated to reduce bias. The competencies needed in the context of industry 4.0 based on a literature review are mastery of state-of-the-art knowledge, technical skills, media skills, coding skills, understanding IT security. The results of interviews with practitioners of the automotive manufacturing industry are in sync with the literature review, but there is a little additional competence, namely process understanding. The technical competency requirements for both data are almost the same, but there are additional competencies delivered by industry practitioners, namely mastery of new technology or state-of-the-art knowledge required in every field of work, and in the field of data analyst work adds one competency, namely process understanding.

Keywords: Technical competencies, manufacture automotive, Industry 4.0, skill

DAFTAR ISI

HALAMAN PERNYATAAN HAK CIPTA	ii
LEMBAR PENGESAHAN	iii
UCAPAN TERIMA KASIH.....	iv
ABSTRAK	v
DAFTAR ISI.....	vii
DAFTAR TABEL.....	Error! Bookmark not defined.x
DAFTAR GAMBAR.....	x
DAFTAR LAMPIRAN	xi
BAB I PENDAHULUAN.....	1
1.1 Latar Belakang.....	1
1.2 Rumusan Masalah	3
1.3 Tujuan Penelitian.....	4
1.4 Urgensi Penelitian	4
1.5 Kebaharuan Penelitian.....	4
BAB II TINJAUAN PUSTAKA.....	6
2.1 Revolusi Industri	6
2.2 Revolusi industri 4.0	8
2.3 Kompetensi Teknologi 4.0.....	12
2.4 <i>Technical & Methodological Competencies</i>	13
2.5 Definisi Persepsi.....	18
2.6 Industri Manufaktur <i>Automotive</i>	19
2.7 Kajian Penelitian Terdahulu.....	19
BAB III METODE PENELITIAN	21
3.1 Paradigma Penelitian	21
3.2 Desain Penelitian	21
3.3 Subjek Penelitian	22
3.4 Instrumen Penelitian	24
3.5 Teknik Pengumpulan Data	24
3.6 Teknik Analisis Data	25
3.7 Teknik Keabsahan Data.....	27
BAB IV HASIL DAN PEMBAHASAN	28
4.1 Temuan Data Kajian Literatur.....	28
4.2 Temuan Wawancara	33
4.3 Pembahasan	35
BAB V SIMPULAN, IMPLIKASI, DAN REKOMENDASI	38
5.1 Simpulan.....	38
5.2 Implikasi	39

5.3 Rekomendasi	39
DAFTAR PUSTAKA	41
LAMPIRAN.....	53

DAFTAR PUSTAKA

- Agrawal, T. (2012). Vocational education and training in India: challenges, status and labour market outcomes. *Journal of Vocational Education and Training*, 64(4), 453–474. <https://doi.org/10.1080/13636820.2012.727851>
- Agrawal, T. (2013). Vocational education and training programs (VET): An Asian perspective. *Asia-Pacific Journal of Cooperative Education*, 14(1), 15–26.
- Albert, A., & Hallowel, M. R. (2013). Revamping occupational safety and health training: Integrating andragogical principles for the adult learner. *Australasian Journal of Construction Economics and Building*, 13(3), 128–140. <https://doi.org/10.5130/ajceb.v13i3.3178>
- Amit, A., & Gati, I. (2013). Table or circles: A comparison of two methods for choosing among career alternatives. *Career Development Quarterly*, 61(1), 50–63. <https://doi.org/10.1002/j.2161-0045.2013.00035.x>
- Aqlan, F., & Nwokeji, J. C. (2019). Applying product manufacturing techniques to teach data analytics in industrial engineering: A project based learning experience. *Proceedings - Frontiers in Education Conference, FIE, 2018-October*, 1–7. <https://doi.org/10.1109/FIE.2018.8658588>
- Azevedo, A., Apfelthaler, G., & Hurst, D. (2012). Competency development in business graduates: An industry-driven approach for examining the alignment of undergraduate business education with industry requirements. *International Journal of Management Education*, 10(1), 12–28. <https://doi.org/10.1016/j.ijme.2012.02.002>
- Azman, A., Simatupang, W., Karudin, A., & Dakhi, O. (2020). Link and Match Policy in Vocational Education To Address the Problem of Unemployment. *International Journal of Multi Science*, 1(6), 76–85.
- Baartman, L. K. J., & De Bruijn, E. (2011). Integrating knowledge, skills and attitudes: Conceptualising learning processes towards vocational competence. *Educational Research Review*, 6(2), 125–134. <https://doi.org/10.1016/j.edurev.2011.03.001>

- Badan Pusat Statistik. (2020). Keadaan Ketenagakerjaan Indonesia Februari 2020. *Berita Resmi Statistik*, 40, 5.
- Bailey, D., De Ruyter, A., Michie, J., & Tyler, P. (2010). Global restructuring and the auto industry. *Cambridge Journal of Regions, Economy and Society*, 3(3), 311–318. <https://doi.org/10.1093/cjres/rsq029>
- Béduwé, C., & Giret, J. F. (2011). Mismatch of vocational graduates: What penalty on French labour market? *Journal of Vocational Behavior*, 78(1), 68–79. <https://doi.org/10.1016/j.jvb.2010.09.003>
- Benešová, A., & Tupa, J. (2017). Requirements for Education and Qualification of People in Industry 4.0. *Procedia Manufacturing*, 11(June), 2195–2202. <https://doi.org/10.1016/j.promfg.2017.07.366>
- Bogdan, B., & Bilken, S. K. (1992). *Quality research for education: An introduction to theory and methods*. 106–156.
- Büth, L., Bhakar, V., Sihag, N., Posselt, G., Böhme, S., Sangwan, K. S., & Herrmann, C. (2017). Bridging the Qualification Gap between Academia and Industry in India. *Procedia Manufacturing*, 9, 275–282. <https://doi.org/10.1016/j.promfg.2017.04.009>
- Carvalho, N., Chaim, O., Cazarini, E., & Gerolamo, M. (2018). Manufacturing in the fourth industrial revolution: A positive prospect in Sustainable Manufacturing. *Procedia Manufacturing*, 21, 671–678. <https://doi.org/10.1016/j.promfg.2018.02.170>
- Chakraborty, S. (2011). Applications of the MOORA method for decision making in manufacturing environment. *International Journal of Advanced Manufacturing Technology*, 54(9–12), 1155–1166. <https://doi.org/10.1007/s00170-010-2972-0>
- Chang, S. (2010). Applications of Andragogy in Multi-Disciplined Teaching and Learning. *Journal of Adult Education*, 39(4), 312–324.
- Chinnasamy, J. (2013). Mentoring and Adult Learning: Andragogy in Action. *International Journal of Management Research and Review*, 3(5), 3710–

3719.

- Cimini, C., Boffelli, A., Lagorio, A., Kalchschmidt, M., & Pinto, R. (2021). How do industry 4.0 technologies influence organisational change? An empirical analysis of Italian SMEs. *Journal of Manufacturing Technology Management*, 32(3), 695–721. <https://doi.org/10.1108/JMTM-04-2019-0135>
- Creswell, J. W., Hanson, W. E., Clark Plano, V. L., & Morales, A. (2007). Qualitative Research Designs: Selection and Implementation. *The Counseling Psychologist*, 35(2), 236–264. <https://doi.org/10.1177/0011000006287390>
- Culot, G., Fattori, F., Podrecca, M., & Sartor, M. (2019). Addressing Industry 4.0 Cybersecurity Challenges. *IEEE Engineering Management Review*, 47(3), 79–86. <https://doi.org/10.1109/EMR.2019.2927559>
- Demir, S., Paksoy, T., & Kochan, C. G. (2020). A Conceptual Framework for Industry 4.0. *Logistics 4.0*, 1–14. <https://doi.org/10.1201/9780429327636-2>
- Detsimas, N., Coffey, V., Sadiqi, Z., & Li, M. (2016). Workplace training and generic and technical skill development in the Australian construction industry. *Journal of Management Development*, 35(4), 486–504. <https://doi.org/10.1108/JMD-05-2015-0073>
- Dilberoglu, U. M., Gharehpapagh, B., Yaman, U., & Dolen, M. (2017). The Role of Additive Manufacturing in the Era of Industry 4.0. *Procedia Manufacturing*, 11(June), 545–554. <https://doi.org/10.1016/j.promfg.2017.07.148>
- Domadenik, P., Far?nik, D., & Pastore, F. (2013). Horizontal Mismatch in the Labour Market of Graduates: The Role of Signalling. *IZA Discussion Paper*, 7527.
- Dwi Riyanti, B. P., Sandroto, C. W., & Warmiyati D.W, M. T. (2016). Soft Skill Competencies, Hard Skill Competencies, and Intention to Become Entrepreneur of Vocational Graduates. *International Research Journal of Business Studies*, 9(2), 119–132. <https://doi.org/10.21632/irjbs.9.2.119-132>

- Ermayanti, E., Anwar, Y., & Santri, D. J. (2021). Analysis of students' creative thinking on plant microtechnical laboratory practices. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 7(2), 111–116. <https://doi.org/10.22219/jpbi.v7i2.12321>
- Falkenthal, M., Breitenbücher, U., Christ, M., Endres, C., Kempa-liehr, A. W., Leymann, F., Zimmermann, M., & Andreas, W. (2016). Institute of Architecture of Application Systems Towards Function and Data Shipping in Manufacturing Environments : How Cloud Technologies leverage the 4 th Industrial Revolution Yonder GmbH , The full version of this publication has been presented as a p. *Proceedings of the 10th Advanced Summer School on Service Oriented Computing, SummerSOC*, 16–25.
- Fang, N. (2012). Work in progress: A new concept mapping approach in an introductory engineering course: Correlation between students' conceptual understanding and problem-solving skills. *Proceedings - Frontiers in Education Conference, FIE*, 3–4. <https://doi.org/10.1109/FIE.2012.6462288>
- Fisher, T. (2015). Welcome to the Third Industrial Revolution: The Mass-Customisation of Architecture, Practice and Education. *Architectural Design*, 85(4), 40–45. <https://doi.org/10.1002/ad.1923>
- Fouarge, D., Schils, T., & de Grip, A. (2013). Why do low-educated workers invest less in further training? *Applied Economics*, 45(18), 2587–2601. <https://doi.org/10.1080/00036846.2012.671926>
- Ghoneim, A. S., Essam, D. L., & Abbass, H. A. (2011). Competency awareness in strategic decision making. *2011 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support, CogSIMA 2011*, 106–109. <https://doi.org/10.1109/COGSIMA.2011.5753426>
- Gokalp, M. O., Kayabay, K., Akyol, M. A., Eren, P. E., & Kocyigit, A. (2017). Big data for Industry 4.0: A conceptual framework. *Proceedings - 2016 International Conference on Computational Science and Computational Intelligence, CSCI 2016*, 431–434. <https://doi.org/10.1109/CSCI.2016.0088>

- Gronau, N., Ullrich, A., & Teichmann, M. (2017). Development of the Industrial IoT Competences in the Areas of Organization, Process, and Interaction Based on the Learning Factory Concept. *Procedia Manufacturing*, 9, 254–261. <https://doi.org/10.1016/j.promfg.2017.04.029>
- Grundy, L. (2001). Pathways to fitness for practice: National Vocational Qualifications as a foundation of competence in nurse education. *Nurse Education Today*, 21(4), 260–265. <https://doi.org/10.1054/nedt.2000.0555>
- Grzybowska, K., & Łupicka, A. (2017). Key competencies for Industry 4.0. *Economics and Management Innovations (ICEMI)*, 1(March 2018), 250–253. <https://doi.org/10.26480/icemi.01.2017.250.253>
- Gunal, M. M. (2019). *Simulation for the Better: The Future in Industry 4.0*. 275–283. https://doi.org/10.1007/978-3-030-04137-3_16
- Haq, M. N. (2017). Paradigma penelitian. *Jurnal Hikmah*, 14(1), 62–70. <http://jurnalhikmah.staisumatera-medan.ac.id/index.php/hikmah/article/download/10/13>
- Helmi, S. A., Eihassani, S., Yusof, K. M., & Phang, F. A. (2018). Enrichment of Problem Solving Skills among Engineering Students through Cooperative Problem Based Learning. *Proceedings - 2017 7th World Engineering Education Forum, WEEF 2017- In Conjunction with: 7th Regional Conference on Engineering Education and Research in Higher Education 2017, RCEE and RHed 2017, 1st International STEAM Education Conference, STEAMEC 2017*, 410–414. <https://doi.org/10.1109/WEEF.2017.8467109>
- Henschke, J. A. (2011). Considerations Regarding the Future of Andragogy. *Adult Learning*, 22(1), 34–37. <https://doi.org/10.1177/104515951102200109>
- Hernandez-de-Menendez, M., Morales-Menendez, R., Escobar, C. A., & McGovern, M. (2020). Competencies for Industry 4.0. *International Journal on Interactive Design and Manufacturing*, 14(4), 1511–1524. <https://doi.org/10.1007/s12008-020-00716-2>

- Ibarra, L., Soriano, A., Ponce, P., & Molina, A. (2019). Research skills enhancement through a research-based wit-learning methodology. *Proceedings of the 2019 20th International Conference on Research and Education in Mechatronics, REM 2019*, 5, 1–7. <https://doi.org/10.1109/REM.2019.8744093>
- Intarakumnerd, P., & Techakanont, K. (2016). Intra-industry trade, product fragmentation and technological capability development in Thai automotive industry. *Asia Pacific Business Review*, 22(1), 65–85. <https://doi.org/10.1080/13602381.2014.990214>
- Jackson, D. (2010). An international profile of industry-relevant competencies and skill gaps in modern graduates. *The International Journal of Management Education*, 8(3), 29–58. <https://doi.org/10.3794/ijme.83.288>
- Jackson, D., & Chapman, E. (2012). Empirically derived competency profiles for Australian business graduates and their implications for industry and business schools. *International Journal of Management Education*, 10(2), 112–128. <https://doi.org/10.1016/j.ijme.2012.04.002>
- Jitpaisanwattana, C., Pathumcharoenwattana, W., & Tantawutho, V. (2015). The Analysis and Synthesis on Education Management for Readiness Preparation of Thai Workforce in Accounting for The ASEAN Community. *Procedia - Social and Behavioral Sciences*, 186, 944–949. <https://doi.org/10.1016/j.sbspro.2015.04.002>
- Kaleem, M. A., & Khan, M. (2020). Significance of Additive Manufacturing for Industry 4.0 With Introduction of Artificial Intelligence in Additive Manufacturing Regimes. *Proceedings of 2020 17th International Bhurban Conference on Applied Sciences and Technology, IBCAST 2020*, 152–156. <https://doi.org/10.1109/IBCAST47879.2020.9044574>
- Kalonde, G., & Mousa, R. (2016). Technology Familiarization to Preservice Teachers. *Journal of Educational Technology Systems*, 45(2), 236–255. <https://doi.org/10.1177/0047239515616965>
- Kannan, K. S. P. N., & Garad, A. (2021). Competencies of quality professionals

in the era of industry 4.0: a case study of electronics manufacturer from Malaysia. *International Journal of Quality and Reliability Management*, 38(3), 839–871. <https://doi.org/10.1108/IJQRM-04-2019-0124>

Kemennakertrans. (2014). Peraturan Menteri Tenaga Kerja dan Transmigrasi Republik Indonesia Nomor 8 Tahun 2014 tentang Pedoman Penyelenggaraan Pelatihan Berbasis Kompetensi. *Peraturan Menteri Tenaga Kerja Dan Transmigrasi Republik Indonesia*, 2009. <https://indolabourdatabase.files.wordpress.com/2018/03/permenaker-no-8-tahun-2010-tentang-apd.pdf>

Kipper, L. M., Iepsen, S., Dal Forno, A. J., Frozza, R., Furstenau, L., Agnes, J., & Cossul, D. (2021). Scientific mapping to identify competencies required by industry 4.0. *Technology in Society*, 64(November 2020). <https://doi.org/10.1016/j.techsoc.2020.101454>

Lasi, H., Fettke, P., Kemper, H. G., Feld, T., & Hoffmann, M. (2014). Industry 4.0. *Business and Information Systems Engineering*, 6(4), 239–242. <https://doi.org/10.1007/s12599-014-0334-4>

Lin, Y. C., Wei, C. C., & Chen, Y. T. (2018). Emotional design: A multisensory evaluation to visual and olfactory perceptions of consumers. *Proceedings of 4th IEEE International Conference on Applied System Innovation 2018, ICASI 2018*, 1292–1295. <https://doi.org/10.1109/ICASI.2018.8394529>

Liñán, F., & Fayolle, A. (2015). A systematic literature review on entrepreneurial intentions: citation, thematic analyses, and research agenda. *International Entrepreneurship and Management Journal*, 11(4), 907–933. <https://doi.org/10.1007/s11365-015-0356-5>

Lui, L. F., Sassenrath, C., & Pfattheicher, S. (2020). When is your pain my gain? The use of perspective taking by everyday sadists. *Personality and Individual Differences*, 167(January), 110213. <https://doi.org/10.1016/j.paid.2020.110213>

Ma, Y. W., Chen, Y. C., & Chen, J. L. (2017). SDN-enabled network virtualization for industry 4.0 based on IoTs and cloud computing.

International Conference on Advanced Communication Technology, ICACT, 199–202. <https://doi.org/10.23919/ICACTION.2017.7890083>

Mahapatra, S. S., & Mohanty, S. R. (2007). Lean manufacturing in continuous process industry: An empirical study. *Journal of Scientific and Industrial Research*, 66(1), 19–27.

Malik, P. K., Sharma, R., Singh, R., Gehlot, A., Satapathy, S. C., Alnumay, W. S., Pelusi, D., Ghosh, U., & Nayak, J. (2021). Industrial Internet of Things and its Applications in Industry 4.0: State of The Art. *Computer Communications*, 166, 125–139. <https://doi.org/10.1016/j.comcom.2020.11.016>

Marciano, B. J. (2018). *he Fourth Industrial. August*, 12–15.

Maryanti, N., Rohana, R., & Kristiawan, M. (2020). the Principal'S Strategy in Preparing Students Ready To Face the Industrial Revolution 4.0. *International Journal of Educational Review*, 2(1), 54–69. <https://doi.org/10.33369/ijer.v2i1.10628>

Mayer, A. V., Müller-Pinzler, L., Krach, S., & Paulus, F. M. (2020). Spinach in the teeth: How ego- and allocentric perspectives modulate neural correlates of embarrassment in the face of others' public mishaps. *Cortex*, 130(July), 275–289. <https://doi.org/10.1016/j.cortex.2020.06.001>

Medvidovic, N., Tajalli, H., Garcia, J., Krka, I., Brun, Y., & Edwards, G. (2011). Engineering heterogeneous robotics systems: A software architecture-based approach. *Computer*, 44(5), 62–71. <https://doi.org/10.1109/MC.2010.368>

Melnic, A., Trandafir, N., & Dumitrescu, C. (2016). The Evaluation of Training Programs in Qualifications for the Automobile Industry in Romania. *Procedia - Social and Behavioral Sciences*, 221, 236–245. <https://doi.org/10.1016/j.sbspro.2016.05.111>

Merians, A. S., Fluet, G. G., Qiu, Q., Saleh, S., Lafond, I., & Adamovich, S. V. (2010). Integrated arm and hand training using adaptive robotics and virtual reality simulations. *International Conference on Disability, Virtual Reality &*

Associated Technologies, 131–138.

Mladineo, M., Gjeldum, N., & Veza, I. (2016). Lifelong learning in Learning Factory. *23rd EurOMA Conference*, 71–88.

Mok, K. H., & Qian, J. (2018). Massification of higher education and youth transition: skills mismatch, informal sector jobs and implications for China. *Journal of Education and Work*, 31(4), 339–352. <https://doi.org/10.1080/13639080.2018.1479838>

Moldovan, L. (2019). State-of-the-art Analysis on the Knowledge and Skills Gaps on the Topic of Industry 4.0 and the Requirements for Work-based Learning. *Procedia Manufacturing*, 32, 294–301. <https://doi.org/10.1016/j.promfg.2019.02.217>

Moses, K. M. (2016). Improving the quality and competence of technical vocational education and training output through vocational school cooperation with industry: A case study of Uganda. *AIP Conference Proceedings*, 1778. <https://doi.org/10.1063/1.4965794>

Mourtzis, D., Vlachou, E., & Milas, N. (2016). Industrial Big Data as a Result of IoT Adoption in Manufacturing. *Procedia CIRP*, 55, 290–295. <https://doi.org/10.1016/j.procir.2016.07.038>

Mourtzis, Dimitris. (2018). Development of skills and competences in manufacturing towards education 4.0: A teaching factory approach. In *Lecture Notes in Mechanical Engineering* (Vol. 0, Issue 9783319895628). Springer International Publishing. https://doi.org/10.1007/978-3-319-89563-5_15

ÖZER, M., & SUNA, H. E. (2020). Türkiye’de Mesleki ve Teknik Eğitim ile İş Piyasası Arasındaki Bağlantı: İstihdam ve Beceri Uyuşmazlığı. *Kastamonu Eğitim Dergisi*, 28, 558–569. <https://doi.org/10.24106/kefdergi.704878>

Pholphirul, P. (2017). Educational mismatches and labor market outcomes: Evidence from both vertical and horizontal mismatches in Thailand. *Education and Training*, 59(5), 534–546. <https://doi.org/10.1108/ET-11->

2016-0173

- Pluta, P. L., & Poska, R. (2011). Process Understanding. *Process Understanding*.
<https://doi.org/10.1002/9783527637140>
- Qin, J., Liu, Y., & Grosvenor, R. (2016). A Categorical Framework of Manufacturing for Industry 4.0 and beyond. *Procedia CIRP*, 52, 173–178.
<https://doi.org/10.1016/j.procir.2016.08.005>
- Richert, A., Shehadeh, M., Plumanns, L., Gros, K., Schuster, K., & Jeschke, S. (2016). Educating engineers for industry 4.0: Virtual worlds and human-robot-teams: Empirical studies towards a new educational age BT - 2016 IEEE Global Engineering Education Conference, EDUCON 2016, April 10, 2016 - April 13, 2016. *EEE Global Engineering Education Conference, EDUCON, 10-13-April(April)*, 142–149.
- Sanchez, M., Exposito, E., & Aguilar, J. (2020). Industry 4.0: survey from a system integration perspective. *International Journal of Computer Integrated Manufacturing*, 33(10–11), 1017–1041.
<https://doi.org/10.1080/0951192X.2020.1775295>
- Schluse, M., Priggemeyer, M., Atorf, L., & Rossmann, J. (2018). Experimentable Digital Twins-Streamlining Simulation-Based Systems Engineering for Industry 4.0. *IEEE Transactions on Industrial Informatics*, 14(4), 1722–1731. <https://doi.org/10.1109/TII.2018.2804917>
- Schweri, J., Eymann, A., & Aepli, M. (2020). Horizontal mismatch and vocational education. *Applied Economics*, 52(32), 3464–3478.
<https://doi.org/10.1080/00036846.2020.1713292>
- Setiadi, N. J., So, I. G., & Suprayitno. (2013). Assessing creativity skill development in art and design among undergraduate students: Implementing creative potential simulation software to capture creativity-relevant personal characteristics. *Proceedings of 2013 IEEE International Conference on Teaching, Assessment and Learning for Engineering, TALE 2013, August*, 268–272. <https://doi.org/10.1109/TALE.2013.6654444>

- Singh, A., HR, I. M. S., & Singh, S. (2021). Investigating Digital Learning Media for Skill Enhancement Programmes. *The Online Journal of Distance Education and ...*, 9(2), 237–246. <http://www.tojdel.net/journals/tojdel/articles/v09i02/v09i02-07.pdf>
- Son, F. (n.d.). *STUDY ON HYDRAULIC MECHANICAL EQUIPMENT OPERATION AND FAULT SIMULATION SYSTEM*.
- Stevenson, A. (2015). *Analytical and Communication Skills Building Course for the Technical Disciplines*. 2015, 1–4.
- Suharno, Pambudi, N. A., & Harjanto, B. (2020). Vocational education in Indonesia: History, development, opportunities, and challenges. *Children and Youth Services Review*, 115(May), 105092. <https://doi.org/10.1016/j.childyouth.2020.105092>
- Suri, K., Cuccuru, A., Cadavid, J., Gerard, S., Gaaloul, W., & Tata, S. (2017). Model-based development of modular complex systems for accomplishing system integration for Industry 4.0. *MODELSWARD 2017 - Proceedings of the 5th International Conference on Model-Driven Engineering and Software Development*, 2017-Janua(Modelsward), 487–495. <https://doi.org/10.5220/0006210504870495>
- Thuraisingham, B. (2020). Cyber Security and Artificial Intelligence for Cloud-based Internet of Transportation Systems. *Proceedings - 2020 7th IEEE International Conference on Cyber Security and Cloud Computing and 2020 6th IEEE International Conference on Edge Computing and Scalable Cloud, CSCloud-EdgeCom 2020*, 8–10. <https://doi.org/10.1109/CSCloud-EdgeCom49738.2020.00011>
- Tuomi, P., Multisilta, J., Saarikoski, P., & Suominen, J. (2018). Coding skills as a success factor for a society. *Education and Information Technologies*, 23(1), 419–434. <https://doi.org/10.1007/s10639-017-9611-4>
- United Nations Industrial Development Organization. (2016). Industry 4.0. Opportunities and Challenges of the New Industrial Revolution for Developing Countries and Economies in Transition. *2030 Agenda and the*

Sustainable Development Goals (SDGs). <https://doi.org/10.1007/978-1-4842-2047-4>

Volovich, K. I., Denisov, S. A., & Malkovsky, S. I. (2021). Deployment of parallel computing in a hybrid high-performance cluster based on virtualization technologies. *Procedia Computer Science*, *186*, 40–47. <https://doi.org/10.1016/j.procs.2021.04.122>

Weaver, A., & Osterman, P. (2017). Skill demands and mismatch in U.S. Manufacturing. *Industrial and Labor Relations Review*, *70*(2), 275–307. <https://doi.org/10.1177/0019793916660067>

Wollschlaeger, M., Sauter, T., & Jasperneite, J. (2017). The future of industrial communication: Automation networks in the era of the internet of things and industry 4.0. *IEEE Industrial Electronics Magazine*, *11*(1), 17–27. <https://doi.org/10.1109/MIE.2017.2649104>

Worley, J. M., & Doolen, T. L. (2015). Organizational structure, employee problem solving, and lean implementation. *International Journal of Lean Six Sigma*, *6*(1), 39–58. <https://doi.org/10.1108/IJLSS-12-2013-0058>

Xu, M., David, J. M., & Kim, S. H. (2018). The fourth industrial revolution: Opportunities and challenges. *International Journal of Financial Research*, *9*(2), 90–95. <https://doi.org/10.5430/ijfr.v9n2p90>

Yen, C. T., Liu, Y. C., Lin, C. C., Kao, C. C., Wang, W. Bin, & Hsu, Y. R. (2014). Advanced manufacturing solution to industry 4.0 trend through sensing network and Cloud Computing technologies. *IEEE International Conference on Automation Science and Engineering, 2014-Janua*, 1150–1152. <https://doi.org/10.1109/CoASE.2014.6899471>

Zhang, N., Demetriou, S., Mi, X., Diao, W., Yuan, K., Zong, P., Qian, F., Wang, X., Chen, K., Tian, Y., Gunter, C. A., Zhang, K., Tague, P., & Lin, Y.-H. (2017). *Understanding IoT Security Through the Data Crystal Ball: Where We Are Now and Where We Are Going to Be*. <http://arxiv.org/abs/1703.09809>

Zwick, D., & Knott, J. D. (2009). Manufacturing Customers: The database as new means of production. *Journal of Consumer Culture*, 9(2), 221–247.
<https://doi.org/10.1177/1469540509104375>