Perceived Design Thinking Mindset Level of Basic Education Mathematics Teachers from Ilocos Region

Melinda Gagaza[1] and Celina Sarmiento[2]
[1] *De La Salle University*
[2] *Philippine Normal University*
**Melinda Gagaza: melinda_gagaza@dlsu.edu.ph*

Abstract: The Industrial Revolution 4.0 (IR4.0) has affected many of the vital processes in the world of work today. With the new industry landscape, a new set of skills and a change of thinking are required of the workforce. Undeniably, this impacts the educational sector as its goal is the production of human resources. One of the expected skills for Industry 4.0 (I4.0) is Design Thinking (DT) – an innovative, complex problem-solving skill that focuses on human needs. Teachers who play a significant role in the curriculum should develop DT to ensure that they are fully equipped for addressing complex problems, innovatively design the lessons, and effectively teach this skill to students in Education 4.0 (E4.0). This study identified the perceived DT Mindset level of Basic Education Mathematics teachers from the Ilocos Region (n=571) through a mixed-methods approach—using descriptive and qualitative methods. Teacher interview responses (n=6) were used to follow up on the quantitative data. In general, the perceived DT mindset of teachers appears to be very high with a mean of 4.23 and a standard deviation of 0.52. The majority fall under a high-level perceived DT mindset composed of 54.8% of the total respondents, followed by a very high level with 44.1%. Based on the interview, it can be affirmed that they possess the set of attitudes of a DT mindset. However, some of the hindrances that teachers faced for more innovative lesson design practices are the lack of support in terms of advanced technology and the affordances of students in terms of technology use in learning.
Key Words: Design Thinking; Industry 4.0; Education 4.0; Mathematics Teachers; Lack of Technology

1. INTRODUCTION

"Global workforce transformation" is now a reality in Industry 4.0 (I4.0) --a term to describe the digitization and automation that happened during the entrant of the Fourth Industrial Revolution. With the rapid adoption of digital technologies—examples are Artificial Intelligence (AI), 3d printing, Internet of Things (IoT), big data, and industrial robots -- business structures have changed and imply a reskilling of the workforce to suit new market demands. This increasing need for automated processes and digitization of work urge human resources to reinvent themselves (Frost & Sullivan, 2018).

Undeniably, the set of new skills required for I4.0 impacts educational sectors as their role is in the production of human capital. However, this demand to shift is more complex than it seemed to be. The educational system faces a drastically changing industry in a short period due to automation processes and the competitive nature of the industry. The World Economic Forum reports that an estimate of 65% of the children entering primary schools will face jobs that have not existed yet (World Economic Forum, 2020). In other words, knowledge and skills learned by the students during their studies may not be applied in their future careers—resulting in a mismatch of skills required by companies. The prevalence of skill gaps in the current industry is identified in the literature. Skills acquired by the

students differ in rank from the required skills for the modern Industry (Rashidah, Humphrey, & Anizahyati, 2019). Furthermore, Rampasso, et al. (2020) identified research gaps related to skills for I4.0 using the 10 work-related skills published by the World Economic Forum which include: people management, service orientation, negotiation, and cognitive flexibility. These scenarios reflect the discrepancy of the current educational system towards addressing the demands of workforce 4.0.

Meanwhile, Education 4.0 (E4.0) is the emerging trend solution in education that curriculum designers continue to improve to align with the needs of Industry 4.0 (I4.0). As the educational system anticipates disruptive changes in the current industry, E4.0 lies in the concept of preparing students for uncertainties such as jobs and technologies which have not existed yet. The main point of this is to "prepare students for what we can't prepare them for" because the educational system is confronted with an imaginary problem (Corrigan, 2013).

The role of teachers is crucial in this era. Teachers as designers of learning have increased over time due to the nature of the pervasiveness of technology in educational use. Learning design acquired popularity to research due to the advancement of technology that transitioned the role of teachers from a source of knowledge to designers of learning (Mor & Craft, 2012). Thus, as the curriculum heads toward a more digitized environment, teachers must be equipped enough to fulfill their role as learning designers. However, the inevitable shift of the current educational system poses some issues concerning teachers. Digital immigrant teachers, in some cases, face difficulty with E4.0 in which the majority of the learners are digitally inclined (Sitepu, Eliyana, & Rosalina, 2020). This technology gap between digital immigrant teachers and these digital native learners is a hindrance in teaching in E4.0 which implies that this era is not just about reinventing the workforce through the students but also reinventing the teachers. To educate students in preparation for I4.0, teachers must have the necessary skills themselves.

A relevant skill currently gaining attention for development is Design Thinking (DT)—a complex problem-solving skill that focuses on human needs. DT is both a process and a mindset that addresses diverse wicked problems through collaboration in the educational context (Panke, 2019). Teachers can adapt to the changes brought by advanced technologies if they start seeing themselves as designers of learning and start to acquire a designer's mindset (Domingo, Sloep, Leo, & Mor, 2017). With DT, difficult educational problems of design can be solved as it provides a clear vision of the problem through empathizing, and providing an optimal solution through iteration (Thienen, Meiniel, & Claudia, 2014) As stated by Henriksen, Richardson, & Mehta (2017), "Design thinking skills may provide habits of mind that benefit teachers in creative problem navigating" (p. 140).

Due to the relevance of DT for I4.0, there have been worldwide initiatives on the development of DT in the world of work and education. However, most educational research on DT focused on the development of this in students which should also be a relevant concern for teachers. This study bridges the gap by providing an insight into the capability of Mathematics teachers with participants from Region I in designing the learning environment by determining the level of teachers' perceived DT mindset. Teachers' perceived DT mindset level with its constructs in this study could inform policymakers for interventions that will improve the teachers' ability and perceived DT that are both beneficial towards designing for teaching and learning in E4.0.

2. METHODOLOGY

This study used a mixed-methods design—descriptive and qualitative. It was participated voluntarily by 571 Basic Education Mathematics teachers of the Ilocos Region through an online survey questionnaire.

The instrument used to determine the level of perceived DT mindset of the teachers was an adopted Design Thinking Mindset Assessment (Dosi, Rosati, & Vignoli, 2018). This instrument is in the form of a 5-point Likert scale from strongly agree (5) to strongly disagree (1). The DT Mindset assessment is made up of constructs—a set of attitudes—characterizing a design thinker. These constructs or DT Mindset indicators were derived through a comprehensive literature review. The construction of items for each construct followed standard criteria set in the literature for developing valid and reliable questionnaires. The initial set of questionnaires was then reviewed by experts for content validity and only questions with greater than 80% Content Validity

Index (CVI) were retained. The modified version of the questionnaire was pilot tested. Gathered data from pilot testing underwent Kaiser-Mayer-Okin's (KMO) test (values need to be higher than 0.5) to determine whether the sample size is enough to extract factors and Bartlett's Test for homogeneity of data before conducting exploratory factor analysis using principal axis factorization. The final version resulted in 22 constructs with 71 items that could be used to measure self-reported. The 22 constructs have three constructs that are divided into two categories. In this study, those two categories in each construct are made into one making only 19 constructs discussed in the results.

On the other hand, the semi-structured interview protocol used for gathering qualitative data is made up of 16 questions that were based on the 22 constructs of the DT mindset questionnaire. The items were made to follow up on the quantitative results of this study. It was reviewed by Habi Education Lab a research group that makes well-designed experiences in Education. The interview was participated by 6 teachers selected through maximal variation sampling.

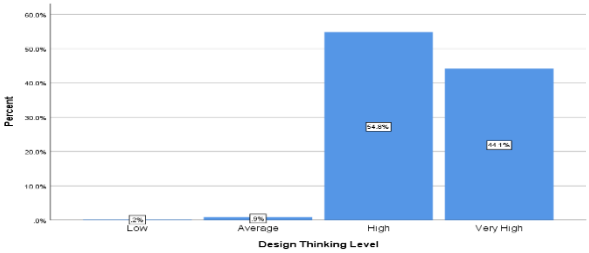
Descriptive statistics were used to determine the level of perceived DT Mindset of Mathematics teachers. Using individual mean scores and conventional Likert scaling, the level of DT was categorized into 5 levels: Very High (4.21-5), High(3.41-4.20), Average(2.61-3.40), Low(1.81-2.60), and Very Low (1-1.80). While One-way Anova was used to determine significant differences between the constructs followed by Tukey HSD post hoc analysis to determine which pairs of constructs have significant differences. Coding analysis was employed on the transcribed interview data. The 22 constructs in the DT mindset questionnaire were the basis for the thematic analysis of the coding process.

3. RESULTS AND DISCUSSION

3.1 Perceived DT Mindset Level

In general, the perceived DT mindset of teachers (n=571) in Region I has a mean of 4.23 with a standard deviation of 0.52, which appears to be very high. Figure 1 represents the percentage of teachers in each DT level.

Fig. 1 Percentage of Teachers in each DT Levels



Most of the respondents which are composed of 54.8% (n=313) of the sample have a perceived DT mindset equivalent to a high level. While second on the list is 44.1% (n=252) of respondents fall under the category of very high perceived DT mindset Level. While no teacher has a very low perceived DT level.

To analyze further this result, Table 1 presents the ANOVA result on the mean of the DT mindset constructs. Based on the Table, there is a significant difference between the means of DT mindset constructs.

Table 1. Mean of DT Constructs ANOVA Result

	n	df	F	p
Between Groups	19	18	48.159**	.000

Note. n is the number of DT constructs
**significant, p<0.01

The Anova result was followed by Tukey HSD post hoc analysis to determine which pairs of DT constructs have significant differences. Table 2 presents the result of the multiple comparisons test.

Table 2. Multiple Comparisons Test

DT Constructs	Mean	Mean Diff. (+) Significant
DT1 Tolerance for Uncertainty	3.86	None
DT2 Embracing Risk	3.86	None
DT3 Human Centeredness	4.27	DT1** DT2** DT9** DT15** DT16**
DT4 Empathy	4.3	DT1** DT2** DT9* DT15** DT16**
DT5 Mindfulness of the Process	4.2	DT1** DT2** DT15**
DT6 Holistic View of the Problem	4.18	DT1** DT2** DT15*
DT7 Problem Reframing	4.30	DT1** DT2** DT6* DT9** DT15** DT16**

DT Constructs	Mean	Mean Diff. (+) Significant
DT8 Team Working	4.36	DT1** DT2** DT5** DT6** DT9** (DT15-DT18)**
DT9 Collaborative Teams	4.14	DT1** DT2**
DT10 Open to Different Perspectives	4.25	DT1** DT2** DT9* DT15** DT16**
DT11 Learning Oriented	4.45	(DT1-DT7)** DT9** DT10** DT13** (DT15-DT18)**
DT12 Experimentation	4.36	DT1** DT2** DT5** DT6** DT9** (DT15-DT18)**
DT13 Experiential Intelligence	4.28	DT1** DT2** DT9** DT11** DT15** DT16**
DT14 Critical Questioning	4.34	DT1** DT2** DT5** DT6** DT9** (DT15-DT17)** DT18*
DT15 Abductive Thinking	4.07	DT1** DT2**
DT16 Envisioning New Things	4.11	DT1** DT2**
DT17 Creative Confidence	4.21	DT1** DT2** DT15**
DT18 Desire to Make a Difference	4.22	DT1** DT2**
DT19 Optimism to Have an Impact	4.35	DT1** DT2** DT5** DT6** DT9** (DT15-DT18)**

Note. Entries in the 3rd column are DT constructs that have a significant positive mean difference from the given DT construct in the 1st column.
*p<0.05, **p<0.01

Based on the table, the two constructs with the lowest mean (m=3.86) are 'Tolerance for Uncertainty' and 'Embracing Risk' and they are significantly lower than the remaining 17 constructs. Questions under these two constructs asked respondents about their degree of comfortability with unfamiliar or unknown situations and if they are willing to take risks or chances with these situations even if these lead them to mistakes.

The next construct with the lowest mean is 'Abductive Thinking' (m=4.07) which is significantly lower than the means of 14 constructs. Under abductive thinking, questions are about the degree of comfortability of the respondents in inventing new solutions for future possibilities and building conclusions despite incomplete information.

The above-mentioned three constructs are similar in the way that they deal with what is unknown or unfamiliar. Teachers might feel unease when exploring new strategies, approaches, solutions, or dealing with an unprecedented event in their profession.

Below are sample responses of teachers during the interview when they were asked how did they feel about the uncertainty in the curriculum brought about by the pandemic.

> *"Sa una po, medyo nahirapan din kasi wala biglaan lahat noon eh. Di kami prepared masyado, especially doon sa learning modality na inooffer namin na modular."* [At first, we find it difficult because these are all unexpected. We are not prepared especially with the learning modality we offer which is modular.]

> *"Lahat parang kumbaga hindi nila alam kung paano mag-adjust. Paano ituturo iyong mga lessons, iyong mga topics dun sa bata in such a way na mas maintindihan nila."* [All of us seemed do not know how to adjust to the situation. How to teach the topics in the module in such a way the the learners will understand.]

The result of the constructs with the lowest mean is not surprising because oftentimes people experience difficulty in dealing with uncertainty and adapting to novel situations. Uncertainties might bring negative emotions when anticipating their negative impact (Anderson, Carleton, Diefenbach, & Han, 2019). Fear of the unknown is the oldest and strongest fear of people. (Lovecraft, 1927 as cited by (Carleton, 2016) This fear is triggered due to the perceived lack of information about a certain situation (Carleton, 2016).

At first, teachers struggled with this unprecedented difficulty that happened due to the health crisis. But sooner, teachers realized that despite being uncomfortable with it they had no choice but to move forward and learned the importance of dealing with uncertainty and new situations, and embracing risk in the process.

> *"The willingness to adapt in our current situation and always willing to take the risk to try new things." "Hindi tayo pwedeng umasa nalang sa usually na ginagawa natin."* [We should not only depend on the things we usually do] *"We should always try to explore... Learn to adapt and then be willing to take the risk for better teaching strategies."*

> *"…kailangan natin mag take ng risk kasi everything na mangyayari, hindi naman natin iniexpect eh. Kailangan maging handa tayo palagi… dapat maging firm lang tayo, maging flexible enough…* [We need to take the risk because everything that will happen is we do not expect. We should be always prepared, be firm, and flexible enough.]

'Tolerance for Uncertainty', 'Embracing Risk' and 'Abductive Thinking' are manifested in the

iterative process of DT since the refinement of a solution or design requires embracing risk, tolerance for uncertainty, and the thinking to move forward despite incomplete information. These are difficult because it requires someone to be courageous enough to move forward despite not having a clear vision of the outcome. But having this mindset encourages innovation as there is a positive strong correlation between creativity and ambiguity tolerance in design (Mahmoud, Shaimaa, & Hamza, 2020).

Meanwhile, 'learning-oriented' have the highest mean (m=4.45) which is significantly higher than the means of 14 constructs. Questions under this construct are about the comfortability of the teachers in learning from their experiences. Teachers see the importance of learning from their experiences and use these as feedback to inform their decisions at present. Similarly, 'Experimentation' with a mean in the second-highest position (m=4.36) which is significantly higher than the means of 9 constructs is related to learning-oriented. Experimentation is the comfortability of the teachers to learn from the mistakes in their experiences. Here are sample excerpts from the interview which uncover both constructs.

> *"…pag nagdedesign kayo, iyong mga mistakes or shortcomings iyon po iyong mga iniincorporate ninyo at binabalikan iyong mga maaaring mga shortcomings sa paggawa ng modules."* [When you are designing, the shortcomings are the things we improve and look back to the possible shortcomings that may have committed in designing the module.]

> *"Nevermind kung magkaroon tayo ng error later on basta gawin natin, try natin."* [Nevermind if we will have error later on but at least we try to do it.] *"We keep on searching."*

> *"Tinatry nating pinapolish na iyon[modules]. Nirerevalidate ulit iyong mga ginawa naming modules to incorporate kung mayroon iyong mga pagkukulang."* [We polish the modules. We revalidate it to make up with the lackings of it.]

'Team Working' is also in the second-highest mean, the same with experimentation (m=4.36), and significantly higher than the same 9 constructs. Questions under this construct asked teachers about their degree of comfortability of working in groups—sharing ideas with teammates or workmates and accepting the group's decision. When asked in the interview about their stand on working in a group versus working individually, here are a sample of their responses:

> *"…mas gusto kong nagshishare [ideas]. Minsan gusto ko ring nakikinig… Gusto ko paring matuto kahit papaano or gusto ko ring matuto from others."* [I like sharing of ideas. Sometimes, I also like to listen. I still want to learn from others.]

> *"…marami pa akong dapat malaman, so hindi ko na masasabing kaya ko na siya mag-isa. So kailangan ko pa din iyong tulong ng ibang teachers…"*[I have many things to know so I could not say that I can do it on my own. I need the help of other teachers.]

Other constructs which are significantly higher than the same 9 constructs are 'Optimism to have an Impact' and 'Critical Questioning' with means of 4.35 and 4.34 respectively.

Questions under 'Optimism to have an Impact' are about the positive mindset of teachers towards overcoming difficulties—to positively think and act towards addressing these problems. When asked teachers in the interview what keeps them going and what qualities should a teacher possess to overcome the difficulties, here are sample responses:

> *"…gusto ko iyong ginagawa ko and siguro it's part of my job, I have to do it …gusto ko paring maging part ng mga teachers na ginagawa parin iyong kaya for the betterment of the learner."* [I love what I am doing and it's part of my job, I have to do it. I still want to be part of those teachers who are doing their best for the betterment of the learners.]

> *"Kailangan maging ano lang tayo, maging kalmado sa sitwasyon. Nu anya iti kaya tayo nga aramiden, ited tayo laeng. Haan tayo nga agriri kasi nga the more na nagrereklamo tayo, the more na hindi nagagawa iyong trabaho natin. Kasla, andito na tayo face the reality, face the situation, saan tayo nga taltalikudan."* [We have to be calm in the situation. We give what we can do. Stop complaining because the more we complain, it consumes the time in doing our work. Let us face the reality--the situation. Don't turn away from it.]

> *"Pag once na merong challenge na dumating, kailangan madami kang extrang solution para doon… madami kang ideya kung paano mo isosolve iyong solution na iyon or iovercome iyong challenge na iyon. Parang, think on a positive side na masosolve mo iyon, na maovercome mo iyon."* [Once there is a challenge, you should have many solutions, many ideas on how to overcome that challenge. We think on the positive side, how to solve and overcome it.]

While 'Critical Questioning' is composed of questions about their curiosity about a problem and to what degree they seek information needed for new situations. This construct was also uncovered in the interview with sample excerpts given below.

> *"Ang dami dami naming naexperience na challenges or problems na naencounter. So, usually, ang ginagawa kasi*

namin, weekly iyon kapag nagreretrieve [modules from students] kami nagkakaroon kami ng meeting ng mga co-teachers ko sa Grade Level namin. Nagkocollaborate kami, brainstorming, kung paano namin isosolve [problems] iyong mga naencounter namin for that week." [We have encountered many problems. So, usually what we do every week whenever we retrieve modules from students, we conduct meeting in our grade level. We collaborate, and brainstorm on how we can solve the problems we encountered for that week.]

"Although talagang it's very challenging talaga kasi kailangan mong, andami mong kailangang iconsider. Kumbaga is finoforesee mo iyong mga capability ng mga learners, ano ung mood nila. Ang dami mong kailangang iconsider sa paggawa ng modular material."[Although it is very challenging because you have a lot to consider. It is like foreseeing the capability of the learners and their mood. There are many things that need to be consider in making modular learning.]

Constructs of the design thinking mindset were revealed in the interview. Given the excerpts from the interview, it can be affirmed that these teachers possess the attitudes of a design thinker which is in support of the high design thinking mindset results in the quantitative data. If these teachers have a favorable DT mindset, then they are good designers of learning and have the ability to address learners' needs. However, it does not reflect the current situation of mathematics education in Basic Education. It is not new that our students have relatively low performance in Mathematics. In the 2019 Trends in International Mathematics and Science Study (TIMSS), the Philippines scored lowest among 58 participating countries in science and with particular emphasis on Math. This was participated by 4th and 8th graders (TIMMS and PIRLS International Study Center, 2019). Also, the Philippines scored below average in Math in the 2018 Programme for International Student Assessment (PISA) (OECD Better Policies for Better Lives, 2018). The results of this study regarding the DT mindset of teachers seem to contradict the current status of Mathematics Education, particularly the performance of students.

Teaching and learning are affected by other factors, one of which is resources. The interview revealed that one of the challenges that they face especially during this pandemic in their lesson design is the lack of resources, particularly technology.

"…nagsend kami through messenger (module), online… 5 to 8, sila lang iyong may internet connectivity." [We sent the modules through messenger. Unfortunately, only 5-8 students were able to access the module.]

"Very minimal, minsan pinapagamit ko din sila ng cellphone para hindi naman boring na puro board and chalk and board iyong ginagamit, minsan powerpoint, iyon lang madalas." [Very minimal on the use of technology. Sometimes, I let them use their cellphone to balance the boredom of board and chalk teaching. Usually, only board and chalk and PowerPoint are the materials I am using.]

"Kulang kasi sa gamit, pero actually maam, naintroduce na ang Geogebra noon. Kaso nga lang sa status ng school, sa case ng school, limited iyong resources." [There is a lack of resources. The use of Geogebra has been introduced; however, the status of the school is that we only have limited resources.]

Although our teachers aim to use advanced technology to support the teaching and learning process, they could not afford to do so because of the lack of it. Design and technology are two inseparable concepts in I4.0 and E4.0. Design thinking is a powerful mindset for innovation and innovation in this digital era is always coupled with technology. In the context of digital transformation, design thinking and advanced technologies go together. The disruptive changes brought by digital technologies require a DT mindset to surpass challenges such as resistance to change, intolerant to ambiguity, and rapid developments (Sarath, 2021).

4. CONCLUSIONS

This study concluded that the mathematics teacher respondents, in general, have a very high DT mindset. This implies that these teachers possess the set of attitudes, and a designer's mindset capable of creating a good design or solution in their teaching. However, Standardized Assessments conducted by TIMMS and PISA seemed to contradict this finding as the performance of students is relatively low compared to other countries. Having a DT mindset is one aspect of making a good lesson design that will address the low performance of students. However, the performance of students is affected by other factors such as the lack of advanced technology and resources for the teachers and learners. Although the teachers have good lesson design, it does not reach a level that incorporates educational trends which a significant part of it demands resources from the learning environment, the teachers, and learners. To unleash the potential of the teachers and to see a more innovative design that conforms to educational trends, curriculum stakeholders must see to it that our teachers and learners are supported with resources particularly advanced technology that plays a significant part in E4.0 and I4.0.

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6. REFERENCES

Anderson, E., Carleton, N., Diefenbach, M., & Han, P. K. (2019). The Relationship Between Anxiety and Affect. *Frontiers in Psychology, 10*. doi:https://doi.org/10.3389/fpsyg.2019.02504

Carleton, N. (2016). Fear of the Unknown. *Journal of Anxiety Disorders, 41*, 5-21. doi:https://psycnet.apa.org/doi/10.1016/j.janxdis.2016.03.011

Corrigan, P. (2013, July 15). *Preparing Students for What We Can't Prepare Them for*. Retrieved from Teaching and Learning in Higher Ed.: https://teachingandlearninginhighered.org/2013/07/15/preparing-students-for-what-we-cant-prepare-them-for/

Domingo, M. G., Sloep, P., Leo, D. H., & Mor, Y. (2017). Learning Design for Teacher Professional Development. *International Journal of Educational Technology in Higher Education*.

Dosi, C., Rosati, F., & Vignoli, M. (2018). Measuring Design Thinking Mindset. *International Design Conference*, 1991-2002.

Frost, & Sullivan. (2018, May 31). *Global Workforce Transformation in the Era of Industry 4.0*. Retrieved from The Growth Pipeline Company: https://ww2.frost.com/frost-perspectives/global-workforce-transformation-in-the-era-of-industry-4-0/

Henriksen, D., Richardson, C., & Mehta, R. (2017). Design Thinking: A Creative Approach to Educational Problems of Practice. *Thinking Skills and Creativity*, 140-153.

Mahmoud, N. E., Shaimaa, K., & Hamza, T. S. (2020). The Relationship Between Tolerance of Ambiguity and Creativity in Architectural Design Studio. *Creativity Studies, 13*(1), 179-198. doi:https://doi.org/10.3846/cs.2020.9628

Mor, Y., & Craft, B. (2012). Learning Design: Reflections Upon the Current Landscape. *Research in Learning Technology*, 85-95.

OECD Better Policies for Better Lives. (2018). *Philippines Student Performace (PISA 2018)*. Retrieved from OECD Better Policies for Better Lives: https://gpseducation.oecd.org/CountryProfile?primaryCountry=PHL&treshold=5&topic=PI

Panke, S. (2019). Design Thinking in Education: Perspectives, Opportunities, and Challenges. *Open Education Studies*, 281-306.

Rampasso, I., Mello, S., Aguiar Walker, R., Gomes, S., Araújo, R., Chagas, J., & Quelhas, O. (2020). An Investigation of Research Gaps in Reported Skills Required for Industry 4.0 Readiness of Brazilian Undergraduate Students. *Higher Education, Skills and Work-Based Learning*.

Rashidah, S., Humphrey, J., & Anizahyati, A. (2019). Essential Skills for Civil Engineering Graduates Towards Industry Revolution 4.0. *Proc. of the IEEE 11th International Conference on Engineering Education (ICEED2019)*, (pp. 137-140). Kanazawa.

Sarath. (2021, August 10). *Impact of Design Thinking on Digital Transformation*. Retrieved from divami: https://www.divami.com/blog/impact-of-design-thinking-on-digital-transformation/

Sitepu, R., Eliyana, A., & Rosalina, M. (2020). The Readiness of Educational Competency in Higher Education in Connecting the Era of Industrial Revolution 4.0. *SHS Web of Conferences*, 1-8.

Thienen, J. v., Meiniel, C., & Claudia, N. (2014). How Design Thinking Tools Help To Solve Wicked Problems. *Design Thinking Research. Building Innovation Research Eco-Systems*, 97-102.

TIMMS and PIRLS International Study Center. (2019). *TIMSS 2019 International Results in*. Retrieved from TIMMS and PIRLS International Study Center: https://timss2019.org/reports/about/

World Economic Forum. (2020, October 20). *The Future of Jobs Report 2020*. Retrieved from https://www.weforum.org/reports/the-future-of-jobs-report-2020/digest