

Using Illustrations to Make Decisions on the Most Appropriate Qualitative Research Methodology: The Industry 4.0 Scenario

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Abstract

Industry 4.0 is viewed as a complex scenario. This complex scenario could be interpreted using illustrations such as sketches or drawings. Ideally, sketches and drawings are useful in illustrating complexity and multiple abstracts from observed social reality. The use of illustrations allows novice qualitative researchers to explore observed social reality in depth with less linear insight. However, few scholars mention the use of illustrations at the research planning stage because most sketches and drawings have been used as tools during data collection merely to understand an interviewee's perspective. Therefore, this article aims to demonstrate the use of illustrations as a tool to facilitate the research process from problem identification to the selection of the qualitative research methodology. Five specific purposes of illustration that significantly contribute to the body of knowledge for effective decision making and are useful tools in delivering information are demonstrated in this article. Based on the illustrations demonstrated in this article, the most appropriate qualitative research methodology is the case study. Overall, the proposed use of illustrations can assist a novice qualitative researcher in determining the appropriate epistemological and ontological stances, as well as their methodology and method, more effectively.

Keywords

novice researcher, illustrations, Industry 4.0, qualitative research methodology, case study

The conceptions of social reality are not easily interpreted, especially by a graduate student who is a novice in qualitative research (Åge & Gustavsson, 2016; Mccaslin & Scott, 2003). It has been found that even qualified researchers, such as sociologists, “are often accused of making use of a naïve and unnecessary formation of concepts to explain truism” (Segerstedt, 1959, p. 1). Misconceptions and the unnecessary formation of concepts may occur when a researcher fails to integrate information from diverse sources meaningfully. The failure to integrate information from diverse sources could be due to different philosophical stances held by different authors, which have led to different choices of paradigms and methods used to portray reality. Thus, understanding the integration of philosophical stances with effective research methods is important to help a researcher to understand social reality more effectively.

In this article, the corresponding author demonstrates the use of illustrations as a knowledge management tool in her research, to assist in constructing the body of knowledge from the observed social reality in order to make the right decision throughout her research journey.

Figure 1 illustrates the research journey and the construction process of the associated body of knowledge (illustrated as simple dashed lines), beginning with the research questions that were viewed from different lenses of the research paradigm (illustrated as different routes). Each route represents the knowledge and understanding obtained from the literature reviewed. The different possible research routes, namely “constructivism and interpretivism,” “positivism,” and other research paradigms (such as pragmatism and the transformative

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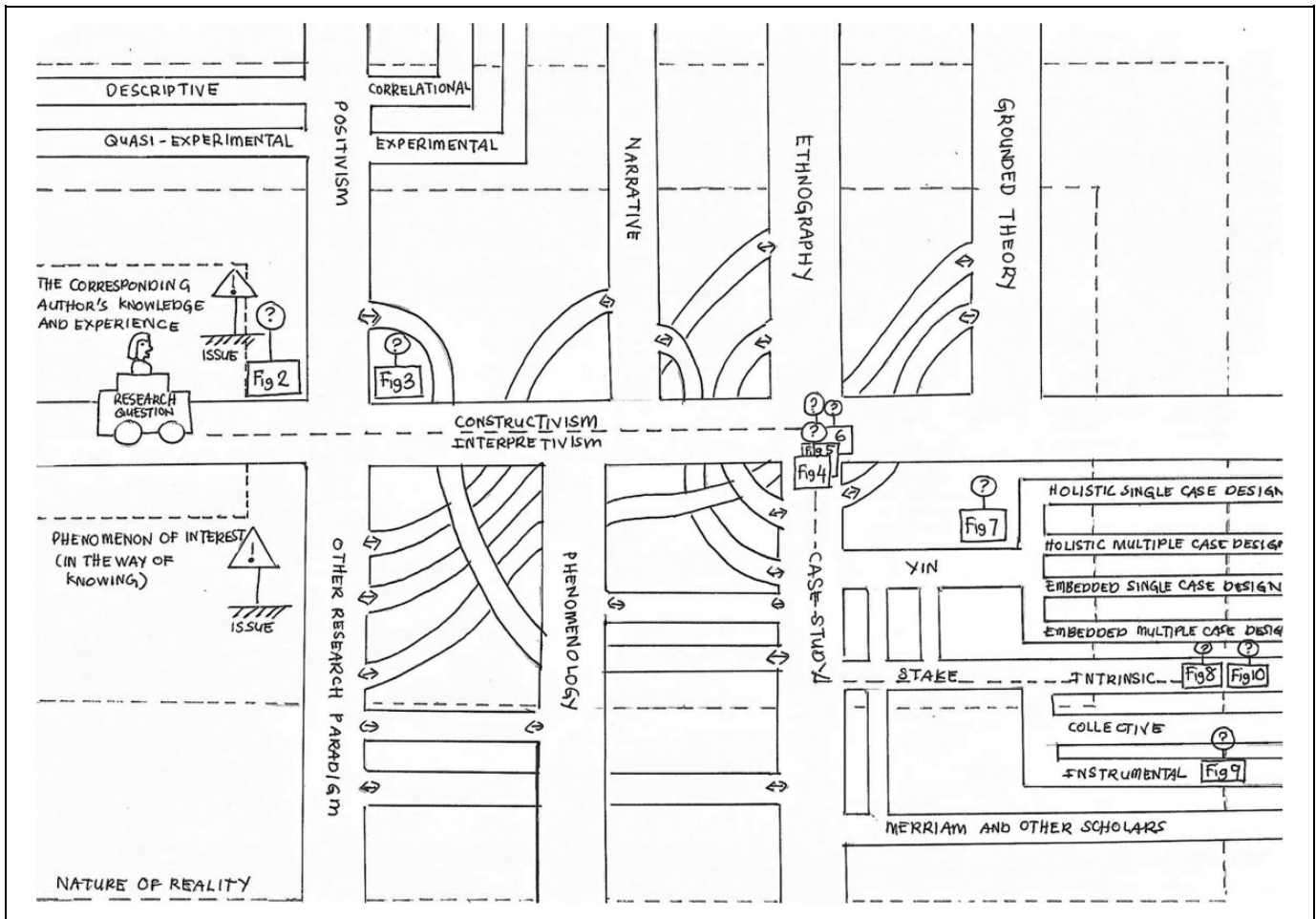


Figure 1. Author's illustration of her research journey as a novice qualitative researcher.

approach; Creswell, 2014; Gray, 2014), are also shown here. The “constructivism and interpretivism” approach was chosen for the reasons illustrated in Figure 2, which are denoted by a question mark. The research journey then continued along the constructivism and interpretivism route (Figure 2). In this study, the terms constructivism and interpretivism are combined as “it is typically seen as an approach to qualitative research” (Creswell, 2014, p. 37).

The confusion among novice researchers in choosing the right research route commonly occurs at the research paradigm stage due to the multiple interpretations that are possible in a single social reality as well as the complexity involved in determining the appropriate research methodology (Åge & Gustavsson, 2016; Salvador, 2016). Therefore, the research question is always referred to during the research process as “it acts as the compass in the research process” (Neri de Souza et al., 2016, p. 7). The research question has a significant influence on a novice qualitative researcher's thinking regarding the way of knowing, how things really are, and how things really work (Scotland, 2012). The question mark in Figure 1 is the basis for subsequent illustrations (in reference to Figures 2–10 in this article) made during the corresponding author's learning

process, including further explanation of decisions made throughout her doctoral research journey.

Next decision-making juncture to be undertaken in the research journey is shown as five routes, in line with Creswell (2007): narrative, case study, phenomenology, ethnography, and grounded theory, which are the options for a novice to choose from to arrive at the most appropriate methodology in qualitative research. Considering the evidence gathered and illustrated in Figures 2 and 3, the author's research journey continues to take on the case study methodology route (refer to the single dashed lines). Three routes of Yin, Stake, and Merriam were possibilities, as illustrated in Figure 1, with reference to Yazan's (2015) case study research. More routes were considered and are illustrated here based on views related to case studies by Yin (2002), Stake (2006), and Merriam (1998). The review of the existing literature about case study research was further conducted and supported by illustrations in Figures 4–6. The specific type of case study was later ascertained with the aid of illustrations in Figures 7–10 to determine the unit of analysis (or case), boundaries, context, and the phenomenon.

The use of the *double-ended arrow* on each route has been observed in various types of research conducted by different

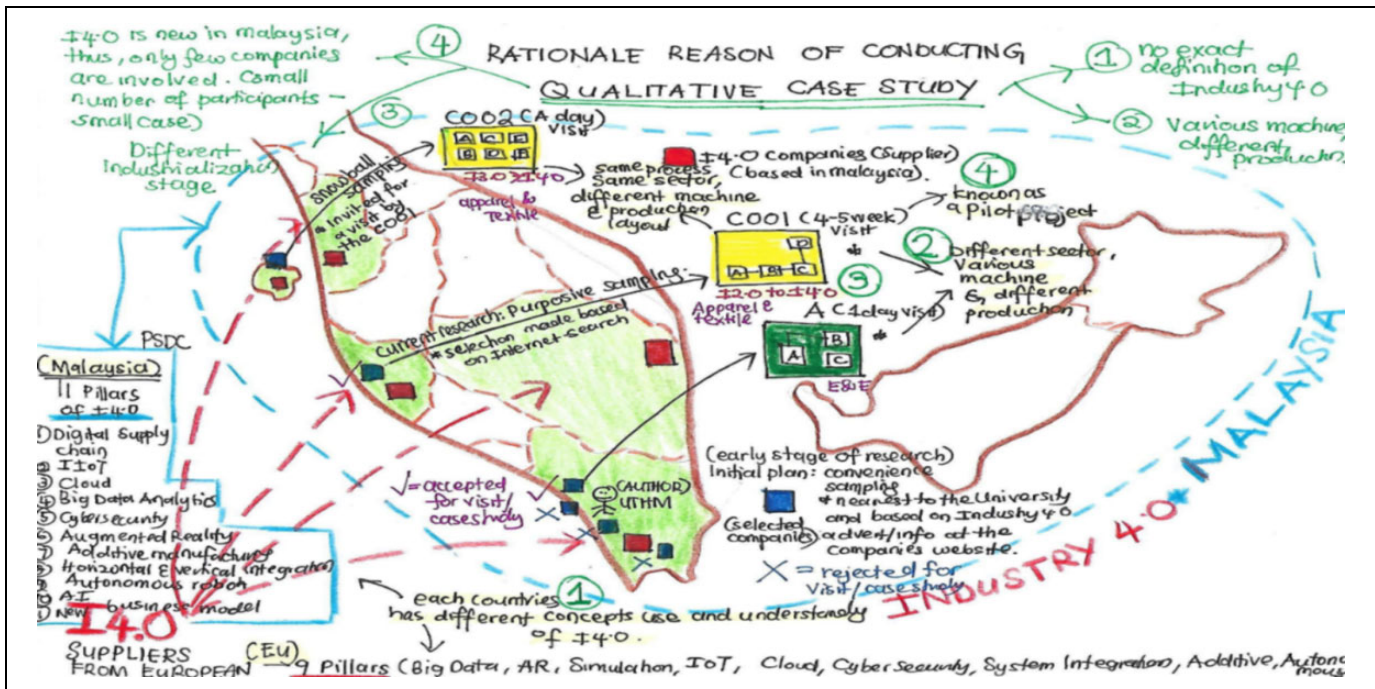


Figure 2. Author's sketch of the Industry 4.0 scenario in Malaysia.

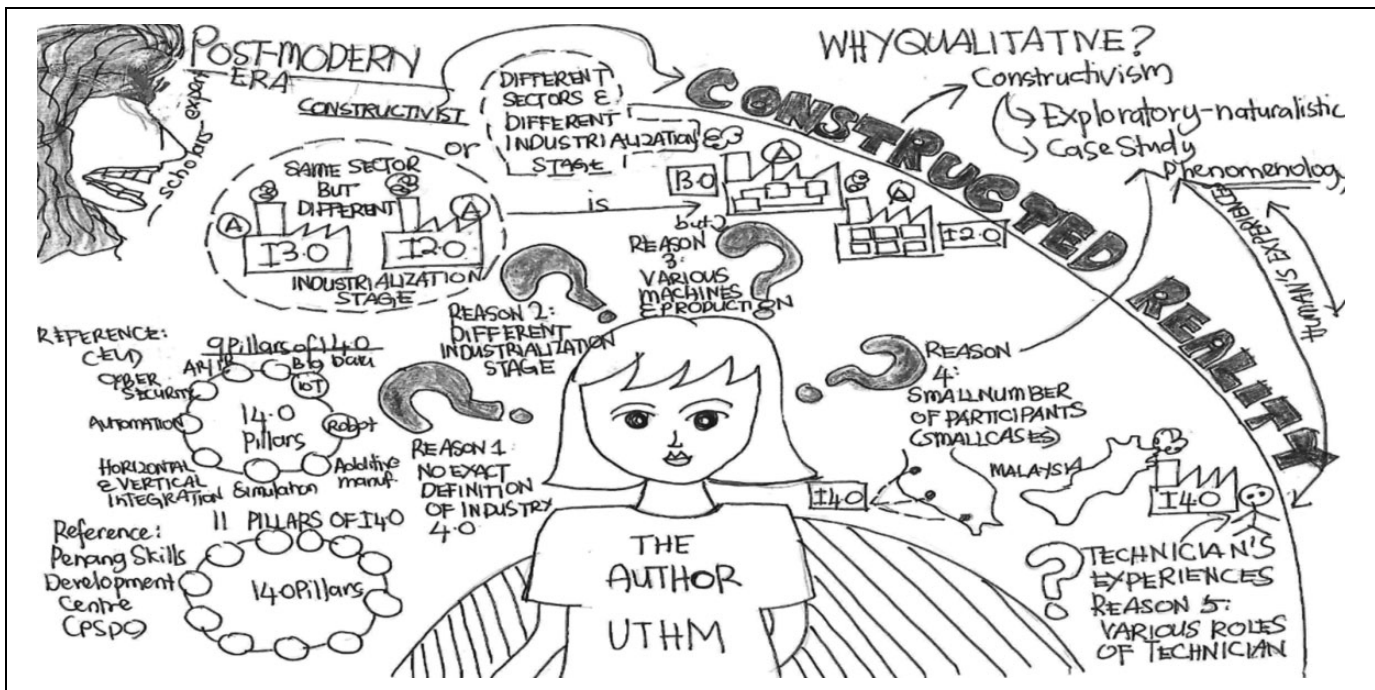


Figure 3. Author's illustration diagram of "Why Qualitative Research?"

researchers in describing their research journey to indicate reciprocity or iteration and knowledge gained from the literature review. For a novice researcher, the confusion in choosing the most appropriate methodology could be influenced by the various types of research obtained from the literature review.

Therefore, following Agee's (2009) advice, reflective and interrogative processes were conducted continuously in developing the research questions in order "to give shape and direction" to the study (p. 431). The case study methodology was then deemed appropriate for the current research question with "multiple

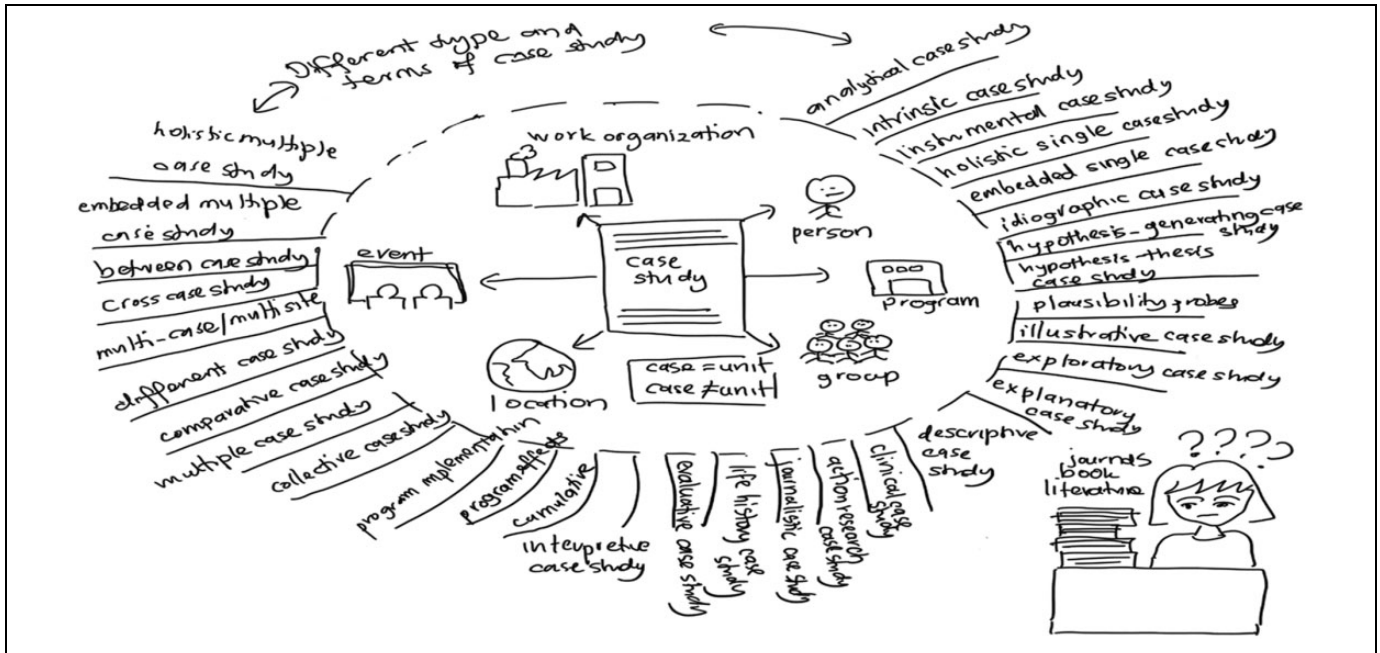


Figure 4. Various types of case studies.

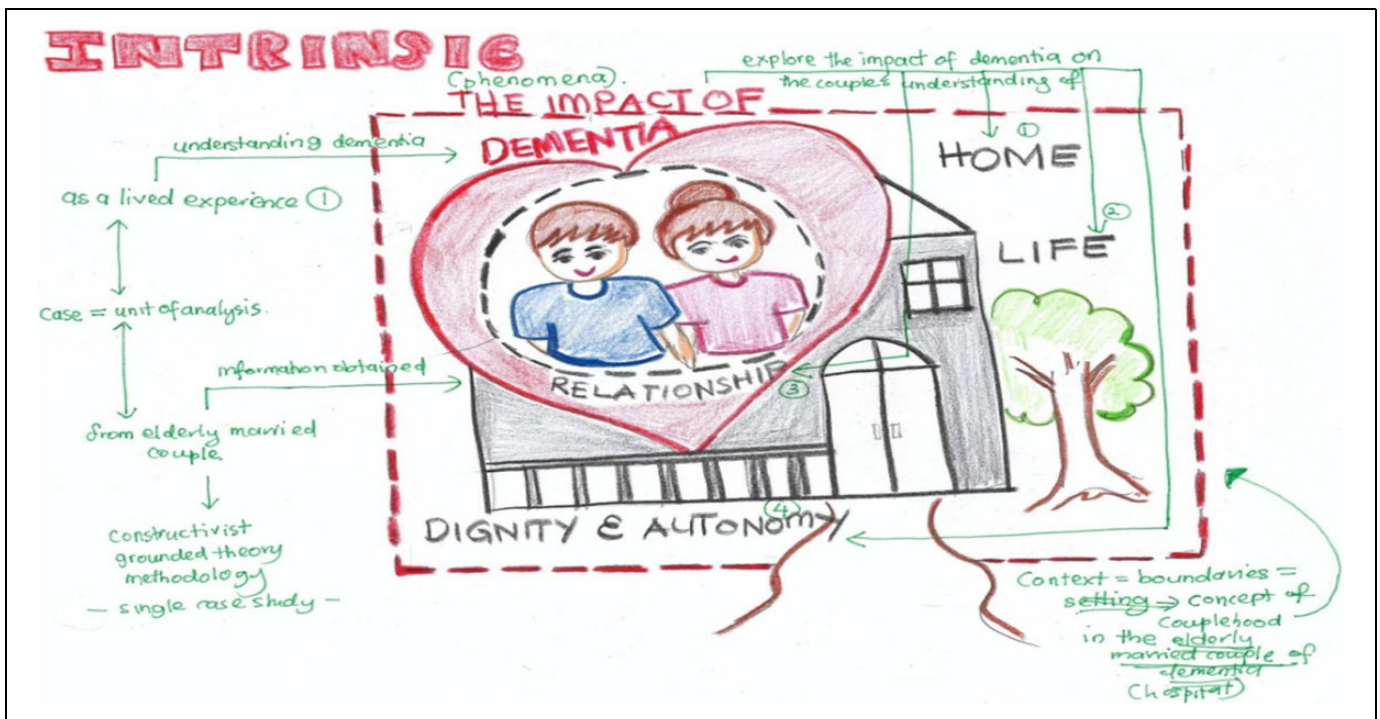


Figure 5. Author's illustration of an intrinsic case study based on a study conducted by Hellström et al. (2005).

routes" to choose from, which could be viewed from either the constructivist lens or the positivist lens (Hyett et al., 2014).

Multiple paradigms such as positivism, constructivism, critical theory, and other research paradigms and perspectives were considered by the authors to understand the current situation and to decide on the appropriate philosophical stance. In this article,

a paradigm is perceived as having four interrelated components: ontology, epistemology, methodology, and method (Scotland, 2012). Kivunja et al. (2017) and Scotland (2012) describe ontology as the nature of reality, while epistemology deals with knowledge definition and acquisition (Kivunja et al., 2017). Understanding the differences between epistemology and

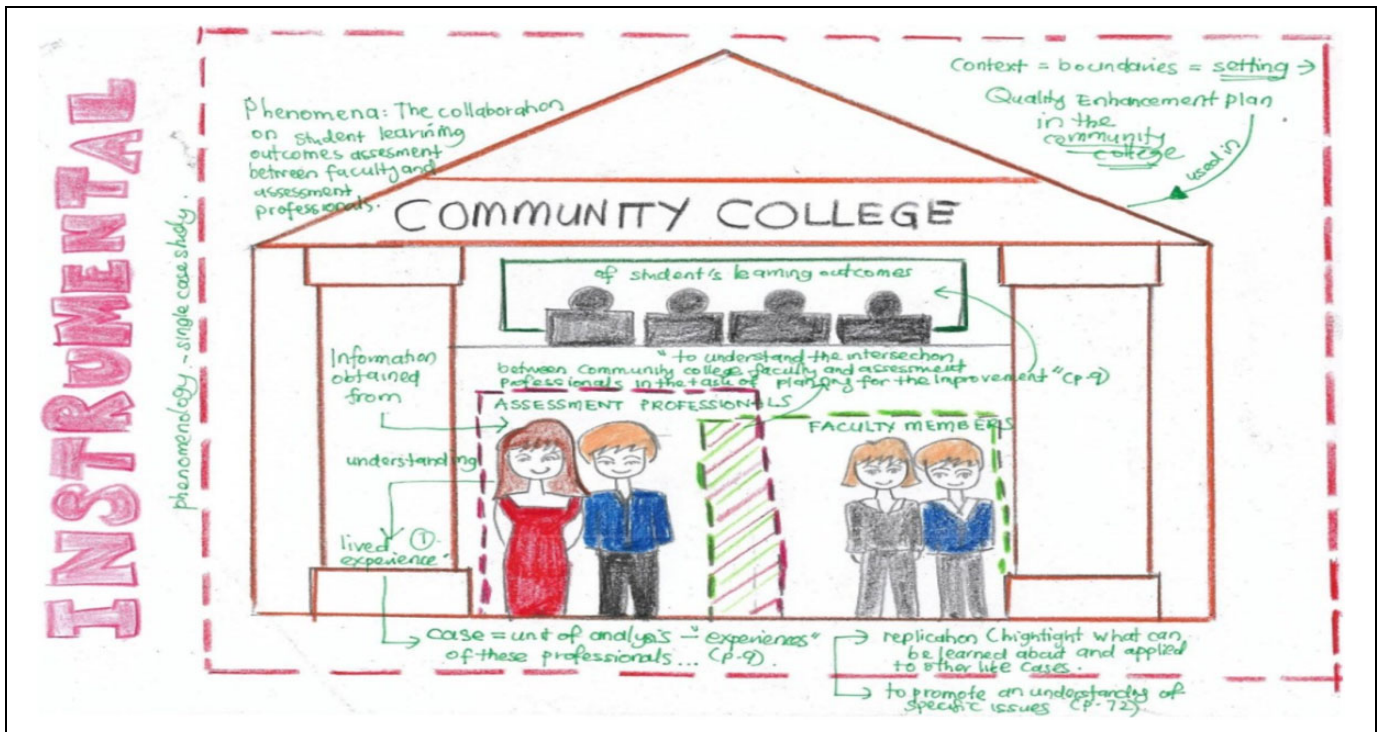


Figure 6. Author's illustration of a single instrumental case study based on Gordin's (2006) study.

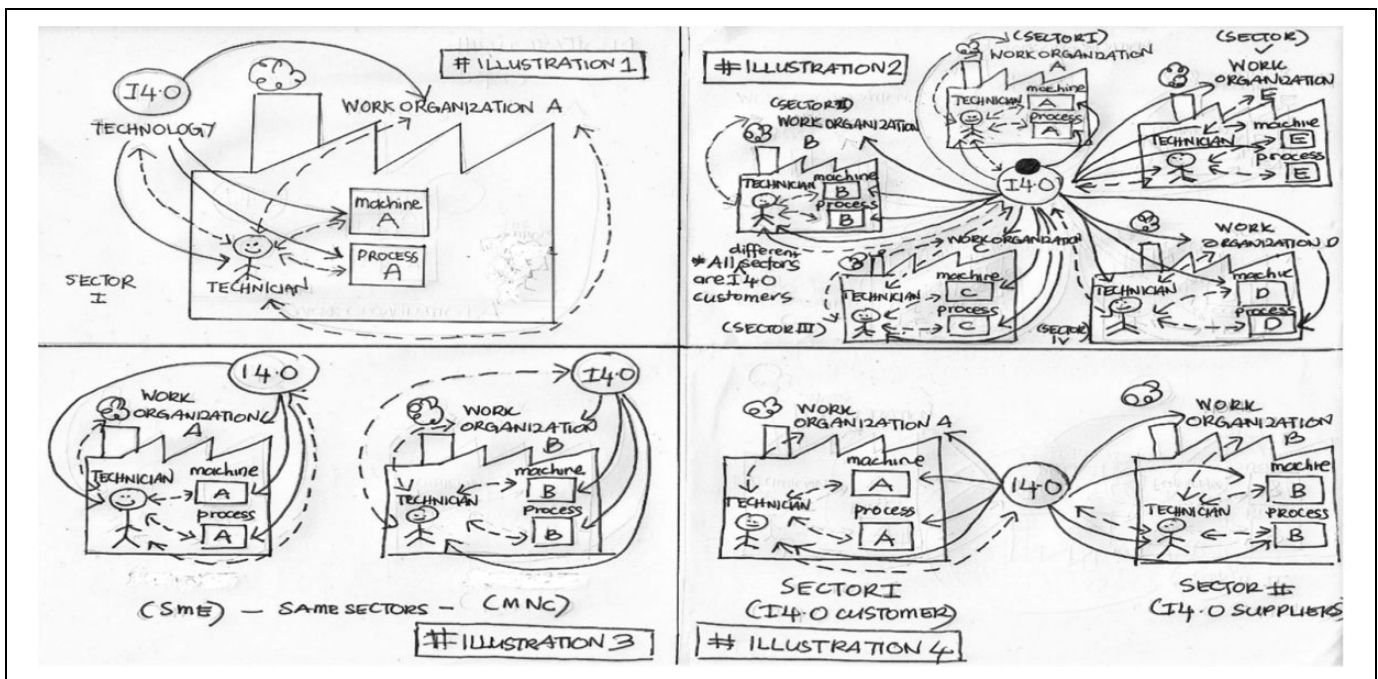


Figure 7. Author's illustrations to understand case study research design.

ontology may justify the use of a particular methodology and method in research. Furthermore, the choice of a research paradigm is influenced by the research inquiry. Agee (2009) ascertains that for “qualitative research questions, there is a need to articulate what a researcher wants to know about, the intentions

and perspectives of those involved in social interactions” (p. 432). Most importantly, epistemological and ontological stances must be aligned with the research questions.

This article presents the construction of ideas for a doctoral study that aims to revise and align the existing polytechnic

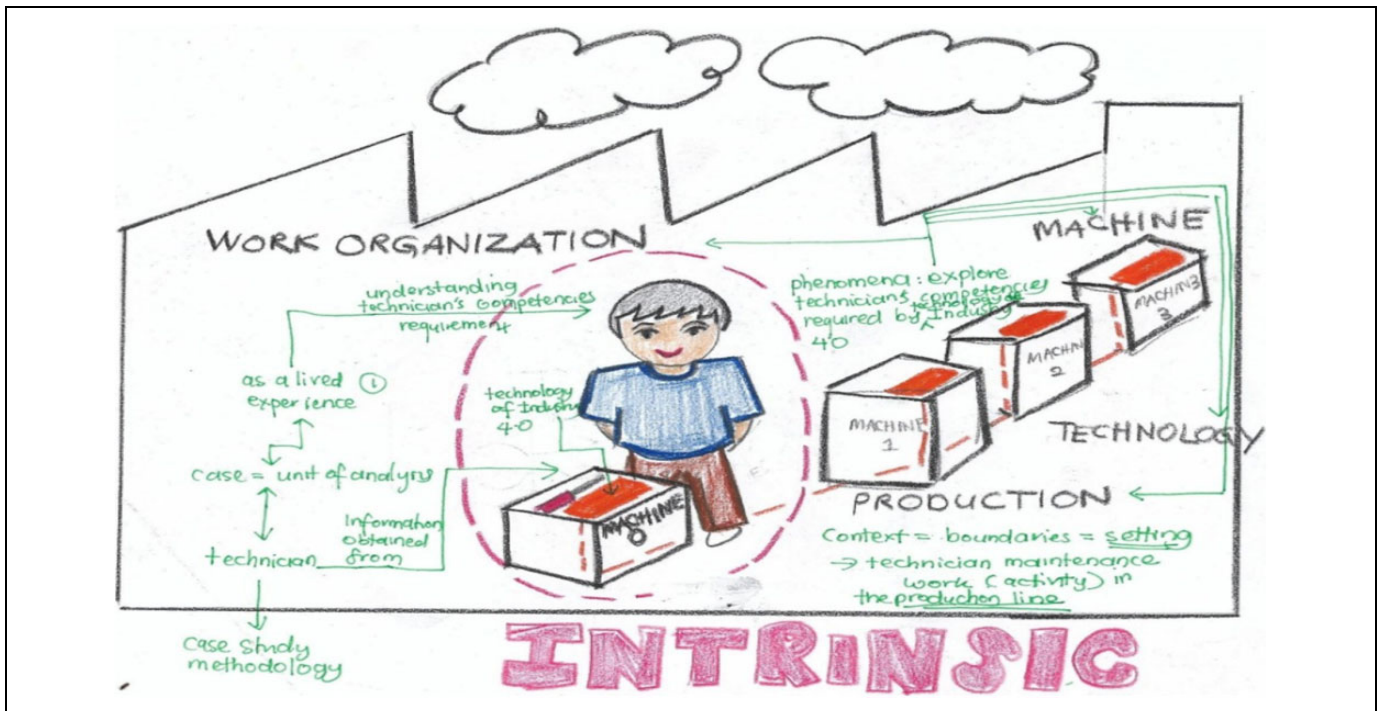


Figure 8. Author's illustration of an intrinsic case study.

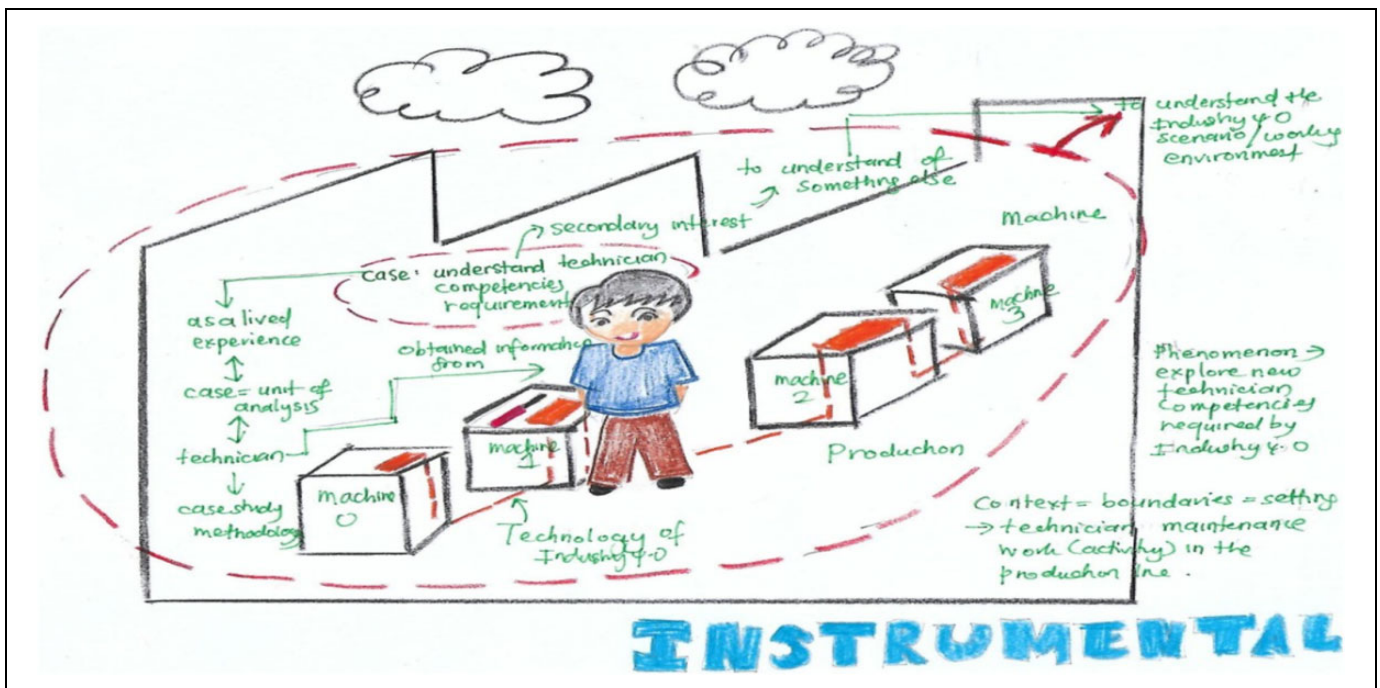


Figure 9. Author's illustration of an instrumental case study.

manufacturing curriculum with Industry 4.0 competency requirements. This study was motivated by the previous work experience of the corresponding author, who was a mechanical engineering lecturer at a polytechnic in Malaysia. The initial research plan was to define new competencies based on the

analysis of competencies derived from the extensive literature and existing curriculum materials. The need to identify new competencies is supported by various studies, which show a lack of mutual agreement on the new required competencies related to Industry 4.0. For example, Prifti et al. (2017) propose

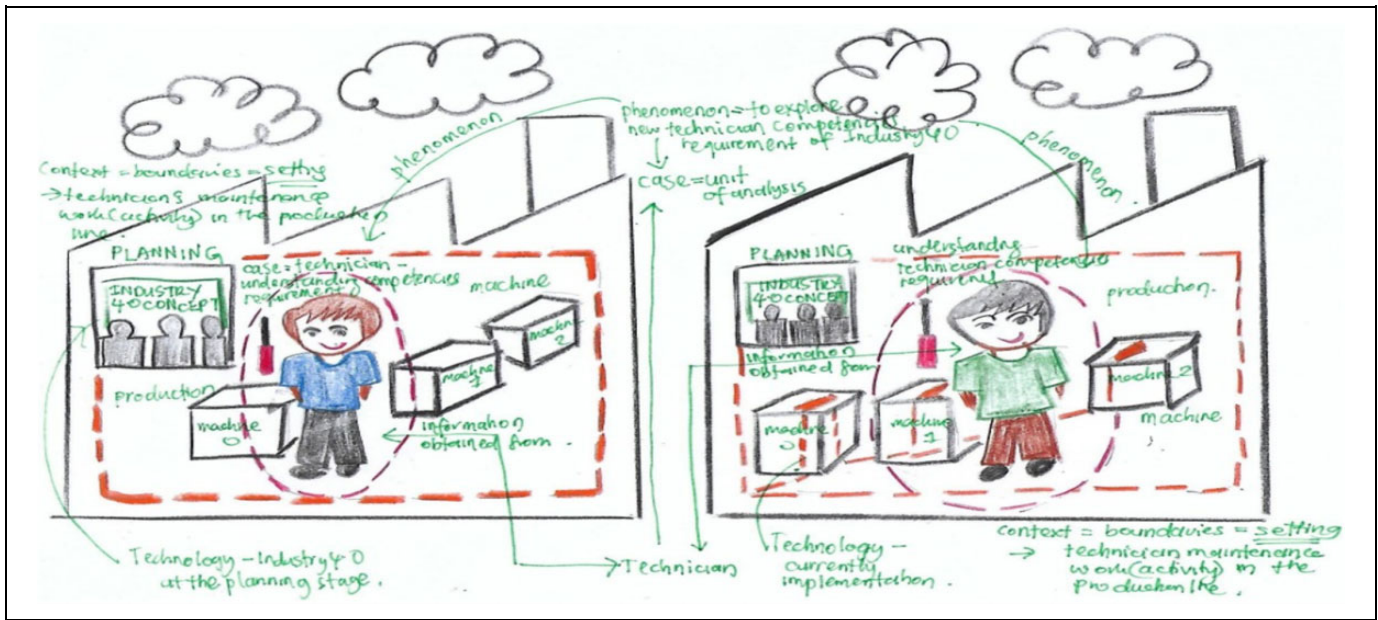


Figure 10. Author's illustration of two different intrinsic case studies.

a model for Industry 4.0 employees, where computer science competencies are emphasized more compared to engineering competencies. Moreover, some scholars—for example, Erol et al. (2016), who discovered “several competencies derived from ‘learning factories,’ such as personal competencies, social/interpersonal competencies, action-related competencies and domain-related competencies” (pp. 14–15), as well as Schallock et al. (2018)—in their research in designing a learning factory for Industry 4.0 suggest “that the learning factory should cover the following three categories of skills” (p. 28) which are technical skills, transformation skills, and social skills. The findings from learning factory studies are deemed relevant to “the path to Industry 4.0” as they represent the actual environment of Industry 4.0 (Baena et al., 2017, p. 73). Based on the initial literature review, the author decided to conduct Industry 4.0 research through a positivist lens. It was felt that listing and comparing competencies from the literature review and existing curriculum materials, together with a survey from the industry (from preliminary research), would be sufficient to propose a model for the doctoral study.

However, the initial ideation was not feasible due to the nature of social reality within the manufacturing sector related to Industry 4.0, which is too complex due to several factors such as lack of knowledge (Moeuf et al., 2017) and the uncertain readiness of manufacturers (Agca et al., 2017) to embark on organizational changes to achieve Industry 4.0 status. Additionally, Industry 4.0 is a new phenomenon in Malaysia. For example, only 12% of Malaysian manufacturing companies were involved in the Industry 4.0 transition in 2017 (*The Sun Daily*, 2017). Furthermore, only five companies in total (including a company from the author's visit) were identified in early 2018 as Industry 4.0 pilot projects, as the Malaysian Government embarked on a pilot project to develop the Internet

of Things (IoT) industry and ecosystem (Yusof, 2018). To date, approximately 500 small-to-medium enterprises (SMEs) have been identified in the Industry 4.0 readiness assessment to be conducted by the Ministry of International Trade and Industry in 2019 (Tan, 2018). These factors, combined with an extensive review of the literature, indicate that the Industry 4.0 concept in Malaysia is not yet well-defined. Therefore, there is a need to view the nature of social reality from a different lens (not positivist) to understand the new competencies for a new manufacturing curriculum revision to be aligned with Industry 4.0.

A good understanding of Industry 4.0 competencies can only be achieved if the constructed reality of the Industry 4.0 scenario in Malaysia is understood. Therefore, it was necessary for the author to understand the Industry 4.0 scenario in the manufacturing sector first. This was supported by a systematic literature review (previously conducted by the authors) on the human role, competencies, and skills required in Industry 4.0 (Janis & Alias, 2018). Most studies on competency, which used quantitative approaches following the positivist research paradigm, were related to evaluation inquiry and the prediction of new competencies. Only limited research focused on actually understanding Industry 4.0 competencies. Research that aimed to understand Industry 4.0 competencies using a qualitative approach was only found in the learning factory research and expert observation, such as the work of Pfeiffer (2016), who observed skilled workers in shop floor production. On the other hand, surveys and Delphi methods of quantitative research are considered suitable to predict or foresee Industry 4.0 competencies in Malaysia, and such studies are limited to Industry 4.0 itself, yet there is no exact definition of Industry 4.0 (Prifti et al., 2017): as similar concepts and visions are often used under another term such as “Smart Factory” or “Digital

Transformation” in the international context which they refer to I4.0 as a German concept concerning the definition in their study.

Therefore, considering the Industry 4.0 literature reviewed, a qualitative approach was adopted to understand the Industry 4.0 scenario within the manufacturing context. The purpose was to understand the new competency requirements from lived experiences as they can “offer in-depth responses to questions about how they constructed or understood their experience” (Jackson et al., 2007, p. 23). However, using a qualitative approach to understand Industry 4.0 is difficult for a novice qualitative researcher, as an extensive body of knowledge is required related to the experiences of working in Industry 4.0 to undertake qualitative research. To overcome these issues, the author took the initiative of using illustrations to develop a body of knowledge during the research process. Here, “author” refers to the corresponding author who was responsible for the illustrations. The illustrations were constructed simultaneously throughout the discussions with the doctoral supervisor on case study research design. Meanwhile, the Industry 4.0 scenario was ascertained by the coauthors who are experts in the engineering field.

Illustrations in the Realm of Novice Qualitative Researchers

Being a novice qualitative researcher, the author experienced a difficult qualitative research journey due to the lack of experience, patience, and in-depth knowledge of social science research. Ausband (2006) suggests to be patient and ready for uncertainties and reminds that “the process is once of continuous adjustment” (p. 769).

Furthermore, Kelly and Bowe (2011) suggest for a novice qualitative researcher “to have a thorough understanding of the analysis method before collecting data” (p. 5). Collecting data in qualitative research requires that the author understands the meaning from observed social reality, and illustrations can be used to assist a novice qualitative researcher in that process. Black (2014) further explains the benefits of using illustrations, such as in knowledge construction, as “research in illustration offers the opportunity to put together these bodies of knowledge... which enabled me to review the concepts’ utility within the making of illustration and in relation to research in illustration” (p. 54).

Black’s (2014) research and her findings on positioning illustration as practice-led research contradict Eisner’s (1997) view on the inclusion of arts in research, as the use of illustrations poses many methodological difficulties (Huss & Cwikel, 2005). Huss and Cwikel (2005), however, proved that using art (the Bedouin women’s drawing) can enhance the understanding of the research context; they found “that art as research can enhance understanding ... by offering a complex, multifaceted expression of the Bedouin women’s concerns, together with their understanding of these concerns” (p. 59).

In another example, Guillemin (2004) used drawings as a research method to understand illness. She emphasizes that the

meaning of illustrations must be explained at three sites: production, the image itself, and its audience. The illustration process in this study can be studied in reference to Rose’s (2001) guidance that visual imagery must always be “constructed through various practices, technologies, and knowledge” (p. 32). Huss and Cwikel (2005) concur that art plays the role of communication, “which can be defined as the association between words, behaviour and drawing created in a group setting” (p. 45).

The use of illustrations allows the author to simplify the complexity of observed social reality. However, the benefits of using illustrations in qualitative research design are limited. For example, Huss and Cwikel (2005) argue that the art product itself, by definition, “creates more gaps and entrances than closed statements or conclusions” (p. 46). Moreover, Mitchell asserts that the use of illustrations for qualitative research might be simple in terms of data collection but complex for data interpretation. For example, “Does one ask for captions? Does one use the drawing as a type of elicitation? What do the drawings really mean?” (Mitchell et al., 2011, p. 2).

Drawings may elicit different interpretations from the researcher (who draws) and the reader. Regardless of multiple interpretations of an illustration among readers, “the act of drawing necessitates knowledge production, with a visual product as its outcome” (Guillemin, 2004, p. 272). Carney and Levin (2002) suggest that the text accompanying an illustration might assist the reader in understanding the meaning behind the illustrations. Interestingly, despite the extensive literature on the benefits and drawbacks of using illustrations in research, it is apparent that most drawings and sketches mentioned by previous scholars were created or used by the participant but not by the researcher. The studies by Buckley and Waring (2013), Mahoney and Vanderpoel (2015), and Rafee et al. (2015) mostly used diagrams or sketches as tools in their qualitative interview processes. Buckley and Waring (2013) list several illustrations to support their grounded theory research process, such as the “simple diagram,” the “hand-drawn data diagram,” “flow-diagram mapping,” and the “visual map.” In another example, Mahoney and Vanderpoel (2015) used illustrated “set diagrams” in their qualitative research; however, they found that “the potential uses of diagrams for qualitative research have not been explored systematically” (p. 65). Meanwhile, Rafee et al. (2015) illustrated in his research, the visual image of the hand gesture study in sketches for drawing analysis.

Accordingly, this article aims to demonstrate the use of illustrations from the researcher’s perspective. Mitchell et al. (2011) used drawing as a visual methodology for picturing their research process; however, few scholars mention the effective use of illustrations at the initial stage of planning qualitative research. Scholarly work on illustrations is lacking because “illustration research is relatively new and still developing” (Black, 2014, p. 15). In this study, instead of using textual representation (text narratives only), illustrations were used as a learning tool to assist in constructing the body of knowledge from the observed social reality. The significance of using

illustrations as a learning tool is supported by Makela et al. (2014), who found that the use of drawings has become widespread. Heideman et al. (2017) concur that drawing aids students in accomplishing learning tasks from the simplest (e.g., developing memory for core content) to the most complex (e.g., hypothesis generation, prediction, and analysis). Using illustrations can help the author to understand observed social reality and plan the qualitative research design effectively.

In this article, there are three major stages in using illustrations, which are (a) “picturing research from the reality to the illustration,” (b) “picturing research from the literature to illustration,” and (c) “picturing research from the illustration to decision making.” Each stage of illustration has several sketches with a specific purpose for each sketch. In this study, simple sketches were used for five purposes to (a) illustrate the Industry 4.0 scenario, (b) determine the qualitative research methodology, (c) simplify the complexity of the literature, (d) illustrate an understanding of the literature, and (e) determine the type of case study.

Picturing Research From Reality to Illustration

At the first stage of “picturing research from reality to illustration,” the use of illustrations such as sketches and drawings is demonstrated in reference to observed social reality. In this study, illustrations were used to address the real issues, as “the varieties of epistemological options that exist are difficult to navigate” (Ward et al., 2015, p. 450).

Purpose 1: Simple Sketch to Illustrate Observed Social Reality

The author’s experience of using illustrations is supported by Zweifel and Wezemaël’s (2012) findings on the benefits of using illustrations in presentations as drawing or sketching could make the perception of a complex system visible to be discussed and researched. Compared to textual information, drawing allows an in-depth and less linear insight into complex situations (Zweifel & Wezemaël, 2012).

In Figure 2, the author’s understanding of the Industry 4.0 scenario in Malaysia is illustrated using pencil-drawing sketches and factual information as text accompanying the illustration (Carney & Levin, 2002). It was felt that the complexity of social reality could be simplified into one landscape (as shown in Figure 2). Furthermore, it is easier for the author to explain the content of the sketches to colleagues or an audience during presentations.

Through sketching, the author has illustrated the current landscape based on her experiences during preliminary research and the literature review. The initial plan was to use convenience sampling because each company that was selected had mentioned the significance of the Industry 4.0 technology on its company website. However, after email communication had been sent and received from each work organization, followed by a telephone call for an initial discussion (to request

approval to conduct the case study), some companies responded that Industry 4.0 had not yet been implemented in their Malaysian branch. Other companies would not allow the researcher to conduct the research for confidentiality or other reasons (e.g., a busy production line or not being available for a visit). In Figure 2, various sites are marked with an “x” to denote companies that “rejected a visit/case study.” A “right tick” indicates that the researcher was accepted either for a visit or to conduct a case study. Overall, four scenarios were identified from the illustration based on the author’s observation and supported by extensive literature (such as news, reports, or government policies). Considering the author’s experiences when conducting preliminary research, it was found that the information obtained from the reviewed Industry 4.0 literature is similar to current Industry 4.0 scenario observed from the preliminary research. For example, different policy maker introduces different concepts and pillars of Industry 4.0 (Laudante, 2017; Penang Skills Development Centre, 2017). Moreover, Industry 4.0 is new in Malaysia, and only a few companies are involved thus far (Mageswari, 2019).

Purpose 2: Simple Sketch to Determine the Qualitative Research Methodology

Using a constructivist approach, the four scenarios from the initial sketch in Figure 2 are further described in Figure 3.

These four scenarios are further defined as reasons for using a qualitative research approach. To understand the technical competencies of the Industry 4.0 scenario, the author had to engage with technical staff working in shop floor production. However, “technical” roles vary, and they include production technicians, IT technicians, and electronic technicians, for example. Thus, the author added another reason (Reason 5) as the various roles of technicians, a factor of the sample size that must be considered when determining a qualitative research design, as illustrated in Figure 3. Considering all this evidence, the case study was selected as the most appropriate qualitative approach to understand the Industry 4.0 scenario holistically. First, a case study naturally belongs to a naturalistic approach (Grünbaum, 2007). Second, a case study is suitable to cover contextual conditions, which are highly pertinent to the phenomenon to be studied (Yin, 2002). Third, case study research involves an in-depth examination of a single case or a small number of cases (Verner & Abdullah, 2012, p. 870). The importance of using a small number of cases aligns with the view of Verner and Abdullah (2012), who highlight the significance of using a small number of units in case study research which is “to gain a greater understanding of why something happened as it did and what else might be important for further investigation” (p. 870).

The author’s participant observation was used to assess the technician who works in an organization that has different industrialization stages. Chesebro and Borisoff (2007) and Golafshani (2003) describe that constructivism, “which views knowledge as socially constructed” (p. 603); therefore, participant observation is required to understand the emerging trend

of Industry 4.0 technology in Malaysia from the technician's point of view.

Picturing Research From the Literature to the Illustration

One of the major challenges faced by novice researchers is synthesizing relevant data with complex literature because, for a novice, "identifying the problem can seem highly problematic in and of itself" (Mccaslin & Scott, 2003, p. 447). Furthermore, "there is often misunderstanding about case study among the graduate students and researchers who are unfamiliar with case study methodology" (Baxter & Jack, 2008, p. 544). In the second stage of "picturing research from the literature to the illustration," the complexity of the literature of case study research design is simplified using a simple sketch, as demonstrated in Purposes 3 and 4.

Purpose 3: Simple Sketch to Simplify the Complexity of the Literature

There are two major issues concerning the case study research design. The first issue is that different terms are used interchangeably: "case," "unit of analysis," "context," "setting," "boundaries," and "phenomenon," which causes confusion among novice researchers. Grünbaum (2007) claims that there is "the existence of ambiguity in the meaning of a 'unit of analysis' and the case itself" (p. 83). Grünbaum's (2007) study identified several scholars who assert that a case is identical with a unit of analysis (Feagin et al., 1991; Patton, 2002; Vaughan, 1992; Yin, 2002). For example, Yin (2002) defines a "case" as a "unit of analysis" (p. 21) in reference to Platt (1992), who holds the view that a case and a unit of analysis are identical. Similarly, Miles and Huberman (1994) define a case as "a phenomenon of some sort occurring in a bounded context. The case is, in effect, your unit of analysis" (p. 25).

On the other hand, some scholars differentiate a case from a unit of analysis. Stake (1995) argues that a "case" is identical to a "bounded system," where he describes a "case" as a "study object" rather than a "unit of analysis." Merriam (1998) stresses, "if the phenomenon you are interested in studying is not intrinsically bounded, it is not a case" (p. 27), and she defines a "case" as an "instance" rather than a "unit of analysis." She argues that "a qualitative case study is an intensive, holistic description and analysis of a single instance, phenomenon, or social unit" (p. 28). Therefore, considering the ambiguity in distinguishing between a case and a unit of analysis, Grünbaum's (2007) study suggests finding out what determines a unit of analysis and how it can be understood (p. 88). Meanwhile, Gerring (2004) proposes that a case study, "as an intensive study of a single unit, be studied for the purpose of understanding a larger class of (similar) units" (p. 342).

In this study, however, the case is defined as identical to the unit of analysis; without the purpose of understanding a larger class of (similar units) as the author shared Patton's (2002) view that "there is no distinction between case and unit of

analysis" (Grünbaum's, 2007, p. 83). The case (unit of analysis) may consist of a person, program, group, location, event, or work organization, as illustrated in Figure 4.

The second issue is that there are various types of case studies and different terms associated with the case study research design, as illustrated in Figure 4. Merriam (1998) defines a "case study" as an analysis of a phenomenon known as a person, program, group, location, event, or work organization. There are various types of case studies such as Stake's (2006) case study; the intrinsic case study (to gain a better understanding of the particular case of interest and not to be used for theory building), the instrumental case study (used to refine theory), and collective case studies (consisting of several instrumental case studies; Baxter & Jack, 2008). Meanwhile, Yin's case study consists of a single, holistic case study, a single, embedded case study, multiple holistic case studies, multiple embedded case studies (Yin, 2002), and more, as illustrated in Figure 4. The various types of case studies are commonly influenced by the underpinning philosophy, research paradigm, and research purpose. For example, they can be exploratory (mainly used to discover a theory or for theory building), descriptive (lack of theoretical framework, yet useful for description and for theory building), or explanatory (for theory testing; Baskarada, 2014; Gerring, 2004; Yin, 2009), which could be used to discover the Industry 4.0 scenario.

In this study, an Industry 4.0 scenario is defined as a "unique case" because few companies are interested and implementing Industry 4.0 technology (see Figure 2). Thus, the case itself is of interest, which meets the "intrinsic case study" attributes described by Stake; however, the findings may have limited transferability (Baxter & Jack, 2008, pp. 548–550). Another option is the collective case study, where a few instrumental cases are studied to gain an understanding. However, a collective case study may be against the basis of selecting a single case study, where "the unusual or rare case, the critical case, and the revelatory case are all likely to involve only single cases, by definition" (Yin, 2002, p. 45). Regardless of the definition, Darke et al. (1998) and Perry (2002) clarify that the decision on the number of cases may depend "on the nature of the research question, the available resources, the study time-frame, and case availability, either breadth (across multiple cases) or depth (within case) may take precedence" (Baskarada, 2014, p. 7). The complexity in case study research is further ascertained by a few illustrations made to demonstrate the author's understanding.

Purpose 4: Simple Sketch to Illustrate an Understanding of the Literature

Considering the different research terms and various types of case study in this study, the use of illustrations helped the author to gain an in-depth understanding of how previous researchers define the terms "case," "unit of analysis," "phenomenon," and "case boundaries" (also known as "setting" or "context"). For example, in this study, two sketches were made in reference to the single intrinsic and,

instrumental case study research design obtained from the literature.

The first example (Figure 5) illustrates an intrinsic case study that was conducted by Hellström et al. (2005), who treated their case as intrinsic rather than instrumental due to its uniqueness, stating that the case “is intrinsically interesting” (p. 12). The *dashed line* indicates the case study boundaries. The *solid line with arrows on both ends* indicates the case (unit of analysis). The *solid line with an arrow on one end* indicates factual information.

Hellström et al. (2005) argue that instrumental case studies “seek primarily to highlight what can be learned about and applied to other like cases” (p. 12), which contradicts their research aim to provide an insightful view rather than replicating the findings of other cases. Based on the literature, the illustration was made in reference to the identification of the case, the unit of analysis, the context or boundaries (setting), and phenomena. In this study, the case was treated as identical with the unit of analysis.

This case study aimed to study an elderly married couple living with dementia. The context or boundary (setting) refers to the concept of couple-hood and the hospital, where “the couples were recruited into the study via an assessment unit at a hospital in South East Sweden” (p. 10). Then, the phenomenon is “to explore the impact of dementia on the couples’ understanding of home, their everyday life and relationships, and their dignity and autonomy” (p. 10).

Figure 6, however, illustrates a single instrumental case study that was conducted by Gordin (2006). The *dashed line* refers to “case study boundaries.” Meanwhile, the *solid line arrow with one ended* refers to the “factual information.” Assessment professionals and community college faculty “is defined as a case or unit of analysis which served as an instrument to understand the intersections between faculty and assessment professionals in improving teaching and learning” (p. 9). The context or boundaries refer to the “development cycle for the college’s Quality Enhancement Plan” (p. 78). Gordin (2006) describes the phenomenon in her study as the “collaboration in the process of improving community college developmental reading and writing instruction” (p. 6). The cases are used to facilitate the researcher’s understanding of the phenomenon within the case boundaries. In Langston’s (2012) research, “the case served as an instrument for studying particular issues related to professional development” (p. 90). Based on the simple sketches in Figures 5 and 6, it was found that the terms “case,” “unit of analysis,” “case boundaries,” “context,” “setting” and “phenomenon” are clearly distinguished and allow the author to use them as a reference in the decision-making process. Additionally, the illustrations help the author to interpret and ascertain the meaning from the literature accurately, regardless of the different languages found in the literature. Based on these illustrations, the author’s knowledge is further constructed and is useful in making decisions effectively and choosing the most appropriate type of case study.

Picturing Research From Illustration to Decision Making

At this stage, further illustrations are made specifically in reference to the case study design proposed by Yin (2002) and Stake (1995). Decision making at this stage helps the novice to ascertain the decision-making process, as Mccaslin and Scott (2003) claim that “planning a qualitative study for the first time tends to be an intimidating venture for graduate students just entering the field” (p. 447).

Purpose 5: Simple Sketch to Determine the Type of Case Study

The case study design for this study was viewed through a constructivist lens, following Grünbaum’s (2007) suggestion that a case study “naturally belongs to a naturalistic approach” (p. 83). Yin’s case study research design and its case study typology were studied and illustrated to explore the limitation of the case study if viewed through the constructivist lens. The case boundaries of the technicians, such as the technician’s job, maintenance tasks, machine, process, technology, and work organization, were treated as the units of analysis (Figure 7).

Figure 7 shows four sketches (Illustrations 1, 2, 3, and 4) based on observed social reality and interpreted either from the author’s personal observation only (Illustrations 1 and 3) or from the Industry 4.0 literature and personal observation (Illustrations 2 and 4). The *dashed line with arrows on both ends* indicates the competency requirement for the technician, while the *solid line with a single arrow on one end* indicates the Industry 4.0 influence factor. All work organizations were anonymous to protect confidentiality. In Figure 7, Illustration 1 describes a single case design with multiple embedded units of analysis and represents an embedded single case study, which allowed the author to gain a deeper understanding of the Industry 4.0 scenario. However, the multiple case study Illustrations 2, 3, and 4 enrich the information on the competency requirements for the technicians, compared to Illustration 1. The multiple case study could be used to enrich this information on the competency requirements for technicians within each situation and across different situations as well as to understand the similarities and differences between cases (Yin, 2002).

Despite the advantages, conducting a multiple case study has some challenges. For example, in Illustration 2, gaining approval from the five companies can be difficult, unless these companies were appointed as part of a government–university collaboration project. In addition, the naturalistic setting of Industry 4.0 may be influenced by the project’s aim. Chesebro and Borisoff (2007) further explain that the “research is viewed as more ‘naturalistic’ if the behaviour studied is restricted as little as possible by the researcher or by the design of research project” (p. 5). As a result, an in-depth understanding may not be achieved fully.

Furthermore, the findings are also restricted to only one pillar of Industry 4.0 technology. Moreover, each sector has a

different business plan and production plants, as indicated in Illustrations 2 and 3 (Figure 7). Each company has different ownership in terms of advanced technologies, as Hassan et al. (2015) explain that “the gap in knowledge and ownership of advanced technologies . . . has always been large” (p. 4).

Differences of ownership in advanced technologies may result in different implementations of Industry 4.0 technology in shop floor production. Dworschak and Zaiser (2014) concur that, “the factual skills needed (such as cyber-physical systems) are dependent on the companies’ choice of design of technology and the work organization” (p. 349). The shop floor production scenario described by Dworschak and Zaiser (2014) is similar to that in Illustration 3 (Figure 7), which refers to the same sector but different company sizes and plants. Work Organization A (in Illustration 3) is described as an SME, while Work Organization B refers to a multinational corporation. Thus, considering all the evidence, Illustrations 2 and 3 may not be feasible for a case study research design. The differences among sectors, the type of organization, and the business areas require many subunits to be analyzed. Consequently, these differences can be some of the factors leading to pitfalls for a novice qualitative researcher, where “they analyze at the individual subunit level and fail to return to the global issue that they initially set out to address” (Baxter & Jack, 2008, p. 550).

In Illustration 4, the different sectors of the work organization were identified. Work Organization A indicates the Industry 4.0 customers, while Work Organization B indicates the Industry 4.0 suppliers. Despite the differences in the nature of business (representing Sectors I and II), both work organizations shared similar Industry 4.0 technology, and both were SMEs, which allowed the researcher to gain an in-depth understanding of a technician’s competency requirements. Based on the literature, mutual networking between the supplier and the customer in Industry 4.0 allows the author to observe the Industry 4.0 scenario as a whole scenario (Moeuf et al., 2017). Thus, considering the Industry 4.0 scenario (between customer and supplier) as a case foundation, it is possible to analyze the technicians from both work organizations (the cases) to generate an in-depth meaning of the competencies required for the technician.

Therefore, comparing Illustrations 1 and 3 and Illustrations 2 and 4, Illustration 4 is the most appropriate case to be studied because the technician in both sectors (Figure 7, Illustration 4) is engaged in the same maintenance activity, compared to the other technician (in Illustrations 2 and 3) who is engaged in a different maintenance activity due to different manufacturing sectors and maintenance requirements. However, in Illustration 4, based on the author’s interview with the Industry 4.0 suppliers, it was found that engineers, not technicians, perform maintenance tasks. Thus, the participant is beyond the research scope, and Illustration 4.0 is not appropriate for this case study. Further illustration is made in reference to Stake’s case study research design. Nonetheless, Illustrations 1, 2, 3, and 4 helped the author to obtain insight regarding defining a case, case boundaries, context, and phenomenon. In comparison to Stake’s case study research design, which is too abstract to

illustrate for a novice qualitative researcher, Yin’s case study research design, however, provides the author with insights on how the case, unit of analysis, and context are illustrated (Yin, 2002). Regardless of developing an insightful view on these terms, the illustrations in this study helped the author to ascertain these terms from a naturalistic approach, as described by Stake (2006): “The qualitative understanding of cases requires experiencing the activity of the case as it occurs in its contexts and in its particular situation” (p. 2).

For example, Figure 8 illustrates an intrinsic case study, illustrating a technician who works in shop floor production. The technician is the unit of analysis, as a lived experience to be studied, whereas the case is defined as Industry 4.0’s new competency requirements for a technician. The *dashed line* indicates technician case study boundaries. The *solid line with arrows on both ends* indicates the case (unit of analysis). Meanwhile, the *solid line with an arrow on one end* indicates factual information. The case is bounded by the technician’s work and activities, such as repair, service, and maintenance, in the shop floor production (which belongs to the work organization associated with the Industry 4.0 concept). The phenomenon refers to the exploration of new competencies required by the technology of Industry 4.0. For example, if the maintenance work and activity are related to new technology (refer to the Industry 4.0 concept) that is outside the scope of the technician’s existing daily maintenance tasks, the technician’s competency requirements are described as new competencies. The case study may be defined as an intrinsic case study due to its uniqueness, where companies may differ in terms of their industrialization stages (Industry 1, 2, 3, or 4), technology and the machines that influence new requirements for a technician’s competencies. Additionally, it was found that the proposition is not compulsory in an intrinsic case study. Baxter and Jack (2008) explain that the “propositions may not be present in exploratory holistic or intrinsic case studies due to the fact that the researcher does not have enough experience, knowledge or information from the literature upon which to base propositions” (p. 552), which is similar to the lack of author knowledge regarding the Industry 4.0 scenario previously described in Figures 2 and 3.

Regardless of the uniqueness, the case study could also be defined as an instrumental case study (Figure 9). No differences were found between Figures 8 and 9 in terms of the case, unit of analysis, case boundaries, setting, and phenomenon. However, the case (illustrated by a *dashed line*, indicating the technician’s case study boundaries) served as a “secondary interest” to understand the phenomenon (illustrated by a *dashed line*, indicating an Industry 4.0 scenario; Baxter & Jack, 2008, p. 549). The technician’s competency requirements are viewed as an instrument for studying particular issues (new competency requirements for a technician) related to new technology (refer to the Industry 4.0 concept). The *solid line with arrows on both ends* indicates the case (unit of analysis), while the *solid line with an arrow on one end* indicates factual information.

Based on the illustrations and after considering Yin and Stake’s case study characteristics and research paradigm, the most appropriate case study research design is an intrinsic case

Table 1. Self-Reflection Using Illustrations and Its Significance to Qualitative Research Methodology and Case Study Research Design.

Research Question: What Are the Competency Requirements of Industry 4.0 for Technicians?

Reality	Stages of Illustration	Purpose of Sketch	Emerging Subquestions to Guide the Illustration	Significance to Qualitative Research Methodology and Case Study Research Design
Industry 4.0	Picturing research from reality to illustration	Purpose 1: Simple sketch to illustrate observed social reality	What is the Industry 4.0 scenario?	To understand the Industry 4.0 scenario
		Purpose 2: Simple sketch to determine the qualitative research methodology	Which qualitative methods are the most appropriate in this study?	To identify the most appropriate qualitative research methodology
	Picturing research from the literature to the illustration	Purpose 3: Simple sketch to simplify the complexity of literature	Which type of case study is the most appropriate in this study to best illustrate the Industry 4.0 scenario	To identify the most appropriate type of case study
		Purpose 4: Simple sketch to illustrate understanding of the literature		To understand the terms (case, unit of analysis, case boundaries, context, setting, and phenomenon)
	Picturing research from the illustration to decision-making	Purpose 5: Simple sketch to determine the type of case study	Which illustration can allow the author to gain an in-depth understanding of the competency requirements of Industry 4.0 for a technician? If using multiple case studies, which of the illustrations is the best to gain an in-depth understanding of the competency requirements of Industry 4.0 for a technician?	To understand the reason for choosing the intrinsic case study compared to the other type of case study

study. In this study, two different intrinsic case studies were conducted upon the companies' approval and viewed through the constructivist lens. Different stages of Industry 4.0 employed in each work organization are illustrated in Figure 10, including two scenarios. The technician in the first panel of Figure 10 works in a company that is at the planning stage to employ the Industry 4.0 concept, while the technician in the second panel of Figure 10 works in a company currently at the implementation stage of Industry 4.0.

In Figure 10, specifically, both *dashed lines* indicate the technician case study boundaries bounded by the maintenance activity in each work organization. The *solid line with arrows on both ends* indicates the case (unit of analysis), while the *solid line with an arrow on one end* indicates factual information. Two different intrinsic case studies allowed the author to conduct observation and interviews to explore the competency requirements of Industry 4.0 for technicians holistically, as it best represents the competency requirements for a technician during the transition process of Industry 4.0 (one of the unique qualities of the phenomenon of interest). The qualitative approach and case study methodology were selected due to the small number of participants (i.e., the industry) and the research needs (i.e., the research aim and research question) to gain an in-depth understanding of the phenomenon of interest. The Industry 4.0 scenario was viewed from the constructivist lens, as it is a new phenomenon to be explored in finding out technicians' competencies required in the manufacturing sector of Industry 4.0.

Conclusions, Limitations, and Recommendations

This article shows that the use of illustrations helps in restructuring a research plan in the decision-making process when choosing a qualitative research design. The use of illustrations is summarized. Table 1 summarizes three major stages in picturing the research: *from reality to illustration*, *from the literature to the illustration*, and *from the illustration to decision making*. Each illustration stage addresses the specific purposes of the sketch, with guided emerging subquestions in understanding the complexity of the Industry 4.0 scenario. Consequently, the use of illustrations helps the author to understand the research phenomenon (the Industry 4.0 scenario), select the appropriate research design (to identify the most appropriate qualitative research methodology and type of case study), and implement research methods more effectively (to understand the case study terms and rationale for choosing the particular type of case study). Illustrations are best used when there is a need to understand the scenario from the constructivist lens, as data are inductively collected and socially constructed from the observed social reality. As qualitative research is iterative in nature, illustrations could be used effectively to assist novice researchers in constructing knowledge. Furthermore, the use of illustrations may consolidate a novice's understanding of different research terms, thus avoiding misinterpretation. Despite the benefits of using illustrations, the illustrations in this study were made

individually from the corresponding author's perspective with subsequent feedback from the coauthors. This study recommends further research on the use of illustrations through group activity, such as focus groups, to ascertain if mutual understanding from the observed social reality could be achieved.

In summary, the qualitative research journey and its "naturalistic" approach may vary according to the constructed reality, which may pose a real challenge to a novice qualitative researcher. However, with the use of illustrations, the researcher can be assisted in understanding and planning the research. The weakness of the illustration could be strengthened by including factual information in the illustration. In a nutshell, the use of illustrations can assist novice qualitative researchers in understanding the research phenomenon, selecting an appropriate research design, and implementing research methods more effectively.


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