Akademika 92(3), 2022: 51-67

https://doi.org/10.17576/akad-2022-9203-04

A Descriptive Phenomenological Study of the Lived Experience of the Creative Design Process among Students of Graphic Design

Kajian Fenomenologi Deskriptif terhadap Pengalaman Rekaan Kreatif dalam Kalangan Pelajar Senireka Grafik

Mohd Hafnidzam Adzmi, Zahari Ishak & Che Aleha Ladin

ABSTRACT

The use of technologies such as Computer-Aided Design (CAD) is significant and has a profound effect on the Creative Design Process. The widely studied process in Creativity research such as Divergent Thinking (DT), Convergent Thinking (CT), and Analogical Thinking (AT) can describe the Creative Design during the process of producing and the implementation of ideas. The article employs the Descriptive Phenomenological method by collecting verbalized data from seven participants who are at the time of this study are enrolled in a Design Course, specifically Graphic Design. Three design projects are designed specifically to collect verbalized data through the think-aloud and stimulated recall method. Another data source that is used to support interpretation are screen recordings of the of the participants Creative Design process. The findings include seven themes that are associated with the experience of Creative Design and are used to describe the Creative Design Process with CAD through DT, CT, and AT and their relationship through the transformations of conceptual knowledge and technical skills. The article then discusses the role of Conceptual and Technical Knowledge that went through the process of selection and mapping in AT to induce DT and CT in ideation and its expansion through the process of learning. Finally, the article will present the limitations of this study and suggestions for future research.

Keywords: Creative design process; divergent thinking; convergent thinking; analogical thinking; Computer-Aided Design (CAD)

ABSTRAK

Penggunaan jenis teknologi seperti 'Computer-Aided Design' (CAD) adalah ketara dan memberi kesan kepada Proses Rekaan Kreatif. Proses pemikiran kreatif yang biasa dibincangkan di dalam kajian Kreativiti seperti 'Divergent Thinking' (DT), 'Convergent Thinking' (CT) dan 'Analogical Thinking' (AT) dapat menjelaskan Proses Rekaan Kreatif dalam menghasilkan dan melaksanakan idea. Kajian kualitatif ini menggunakan kaedah 'Descriptive Phenomenology' dengan mengumpulkan 'verbalized data' dari tujuh peserta, dimana ketika kajian ini dijalankan sedang melalui pembelajaran kursus Rekaan Grafik. Data bagi kajian ini diperoleh secara 'verbalized' melalui kaedah 'think-aloud' dan 'stimulated recall' melalui tiga projek rekaan yang berbeza dengan menggunakan perisian CAD tertentu. Kajian ini mengumpul juga data didalam bentuk yang lain seperti rakaman skrin. Ia digunakan sebagai sokongan untuk menginterpretasi Proses Rekaan Kreatif. Hasil dapatan kajian telah mendedahkan tujuh tema yang dialami oleh peserta kajian yang dimana ia berkai t rapat dengan Proses Rekaan Kreatif. Tema ini juga merangkumi penjelasan proses kreativiti dengan CAD melalui DT, CT dan AT yang dihubungkan melalui transformasi maklumat konsepsual dan teknikal. Dari tema tersebut, artikel ini membincangkan pula peranan maklumat Konseptual (Conceptual Knowledge) dan teknikal (Technical Knowledge) yang melalui proses 'analogical selection' dan 'analogical mapping'untuk mendorong DT dan CT di dalam pembentukan idea dan pengembangannya melalui proses pembelajaran. Artikel ini diakhiri dengan penjelasan beberapa batasan kajian dan cadangan untuk kajian di masa hadapan.

Kata kunci: Creative design process; divergent thinking; convergent thinking; analogical thinking; Computer-Aided Design (CAD)

INTRODUCTION

Recently, the computer revolution in the 1980s allowed the development of programs that stimulate the growth of the design practice. These technologies encourage new ideas to be tested faster and thus minimize the cost of producing prototypes and shortens the time needed for the realization of ideas. And as the capacity of computers is increasing (Moore 2015), more development of robust programs fulfils the needs of production in Design and its sub-discipline. Graphic Design is one of Design sub-disciplines that requires the extensive use of technologies such as Computer-Aided Design (CAD) systems, and hence become the discipline that this paper chooses to study. The use of CAD in this article is directed towards creativity and digital content creation. The main reason for the use of the terminology of CAD in this study is due to the immense study of its relationship with creativity, the practice of design and its analogous purpose as a visualization tool in the field of Graphic Design.

DESIGN AND CAD SYSTEM

Among the common technologies for designers today are Computer-Aided Design System or CAD. Graphic Design as a sub-discipline utilizes these technologies in creating and experimenting with the production of visuals as it allows image editing and manipulation. The advent of CAD systems such as Adobe Photoshop and Adobe Illustrator provides features that significantly increase the capability to produce, manipulate, enhance, or embellish visual representations (Paul 2008; Bailey 2020). Furthermore, as the capacity of computers to process inputs increases, so does the ability for designers to depict more dynamic images that shapes how visuals appear on mass media. Other than providing accuracy, the computer or CAD system is much more efficient in linking projects or tasks across multiple CAD platforms and features. The increase of memory in computers allows the storage of actions and therefore provides greater flexibility in reverting to previous versions of an artwork. This greatly aid designers to think creatively through recollections and reflections.

CREATIVE DESIGN PROCESS IN GRAPHIC DESIGN

Creativity research theories can be used to investigate the inner workings of thought during the Creative Design Process. It is significant to understand how designers genuinely think, to inform educators so that better instructions and evaluation strategies in educational settings can be appropriately employed (Laurillard 1982). Creativity is defined as creating something that is new and useful (Runco & Jaeger 2012). While design is defined differently, creating new and useful products are inherent to the design ethos. The competencies in producing ideas using CAD systems such as Adobe Photoshop and Adobe Illustrator indicates its purpose as a tool for turning symbolical representation or ideas, to figural representation or visual images (Ayman-Nolley 2010). The production of ideas, either singular or in various categories, and elaborating using tools is an indicator of Divergent thinking; one of the common thinking processes that is associated with creativity especially in predicting creative potential (Runco & Acar 2012). Others highlight the role of analogical reasoning or Analogical Thinking (Holyoak & Thagard 1995). Framing the design process through creativity theories might provide useful insights on how designers think with CAD and subsequently contributes to the design literature.

ISSUES ON CAD AND CREATIVITY

Free relationship, the issue of control, technical rationalities, and mind entrapment are among the philosophical discussions that highlight the concerning consequences of using technologies (Marcuse1964, Heidegger 1977, Kanisauskas 2016, Feenberg 2017). Despite the broad contexts of philosophical discussions, some of the critique rings true. As previous studies and discussions have shown that CAD systems distracts the design process from core tasks (Robertson & Radcliffe 2009) and diminish critical thinking on visuals (Lawson 2002). Other studies show the simplification of the design process (Brown 2009) and favoring new features over ideation (Bonnardel & Zenasni 2010). These studies indicate that the CAD systems at times hinder creativity by obstructing the production of new ideas as the process becomes too reliant on CAD systems. Moreover, this also shows that there is a unique pattern to the Creative Design Process with CAD.

The discussions on the effects of CAD still continues in the present literature. As research on creativity and CAD offers mix results, it is suggested that novices such as students are properly educated on its use to avoid the illusion of being creative

(Alipour 2020). One such study that provides mixed results on the use of CAD finds that while it allows high idea enactment, its effectiveness rely on creative self-efficacy; although it is effective among weak self-efficacy individuals, it can hinder more abstract thinking (Schweitzer & Robert 2021). In another study, the activity of design shift more towards reasoning instead of ideation especially within the phase where CAD tools are used (Shih & Sher 2021). These various result shows the complexity of creativity in different contexts which in turn requires different theoretical orientations (Fasko 2006). While the interest on creativity and CAD remains relevant, its study in the context of graphic design or visuals is still an area yet to be fully explored, especially in areas of instruction and learning by which the findings of this study can be used (Jiajun et al. 2019).

With the discussed implications of technologies such as CAD in creative Design and the context imbued with it, begs the question of its description. And thus, this paper attempts to address the question below:

RQ: what is the relationship of the creative design process with CAD systems?

This question is significant to reveal the types of processes involved during the design process with CAD and in turn provide a transferable account of creativity within the fields of graphic design.

TYPES OF CREATIVE PROCESSES

DIVERGENT – CONVERGENT CONTINUUM

Guilford (1956) described that Divergent thinking (DT) is a production process indicated by the ability to produce many ideas (fluency), produce ideas in categories (flexibility), and the ability to add details towards completion (elaboration). In graphic Design, fluency and flexibility of ideas happens when designers think of possible solutions, and elaboration is when ideas are manifested through technical skills. According to this definition, the creative process in graphic design has two aspects. Firstly, there is a period whereby the creative process happens at a symbolic level by which ideas are produced to generate solutions. Elaboration on the other end happens at figural level where technical skills such as CAD techniques is utilized to manifest ideas into products or artefacts.

Although DT can predict creativity, it is not necessarily synonymous (Runco 2008). Therefore, it is usually complemented with Convergent Thinking (CT). Closely tied to knowledge, CT is a process that generally leads to one answer (Cropley 2006). In Graphic Design, CT is used to determine appropriate techniques, concepts, and to respond to problems. Figure 1 shows the relationship between DT and CT at the symbolic level.

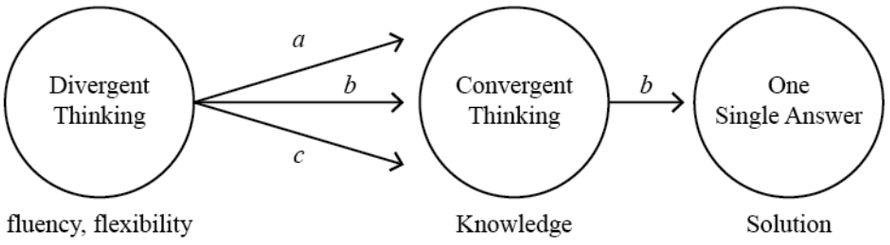

FIGURE 1. Ideas (a, b and c) produced by DT is concluded by CT(b).

There is evidence that DT and CT happen concurrently in the creative design process (Goldschmidt 2014, 2016). This is perhaps due to the constructive and iterative manner of the design process (Brown 2008; Cross 1982). Therefore, CT and DT complement each other as ideas are required to be new and appropriate.

ANALOGICAL THINKING

Elaborations in DT and determining appropriateness through CT shows the use of relevant knowledge in Graphic Design. As one of the basic components in creative cognition (Runco & Chand 1995), knowledge is represented through procedural (technical skills in CAD) and declarative knowledge (visual theories and concepts). The inferring

between two different domains of conceptual and technical skills indicates the process of Analogical Thinking or reasoning (AT) as it is commonly used as a framework to describe the merging of different knowledge to yield new ideas and solutions. As illustrated in Figure 2, when two different knowledge is presented, AT will *select* concepts from one source and *map* it to a target (Holyoak & Thagard 1995). This process gave room for the induction of new or more abstract schemas (Gick & Holyoak 1983). To a certain extent, AT enables learning as difficulties in mapping two different knowledge can reveal its higher-order structural representation. The process of *selection* and *mapping* is the focus of AT for this study.

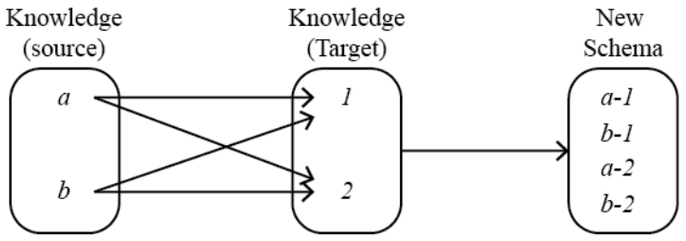

FIGURE 2. Concept from a source is selected and mapped to a target and produced a schema with possibilities

AT is representative in Graphic Design through the connection between ideas and its technical strategies for implementation. For example, expressing ideas through digital painting is complemented with the use of CADs such as Adobe Photoshop (Ps) due to its similarities; just how a painter uses a brush, Ps provides a relative feature called the 'brush' tool. Therefore, the idea of painting in CAD is possible as it is mapped seamlessly. In a different strategy, it is possible as well to express ideas through the creation of shapes and texts instead. This type of strategy or solution requires a CAD system that is different from Ps such as Adobe Illustrator (Ai) (Lupton & Phillips 2015), that utilizes Vector-based processing and therefore capable of depicting precise lines and shapes. Therefore, tasks that is common in graphic design such as typographic elaborations are analogous to Ai as typography is a craft that appreciates the accuracy of shapes and lines. The challenge to select appropriate techniques and tools according to different tasks and strategies shows the significance of AT. This is shown by several studies of AT in different design situations (Dahl & Moreau 2002; Cubukcu & Cetintahra 2010; Alipour et al. 2017).

Based on the literatures presented, this study is framed within the understanding that the creative design process with CAD in Graphic Design is an interplay between AT, CT, and DT. The symbolic nature of AT makes it a candidate process prior to DT. Due to the closeness of CT with knowledge, this study frames it on both at symbolic and figural level because it is used in evaluating concepts and to conform the features of CAD. Although *ideational fluency* and *flexibility* is symbolic, this study frames DT at the production level as elaborations are figural responses and thus a direct representation to visuals. The overall framing of this study is illustrated in Figure 3.

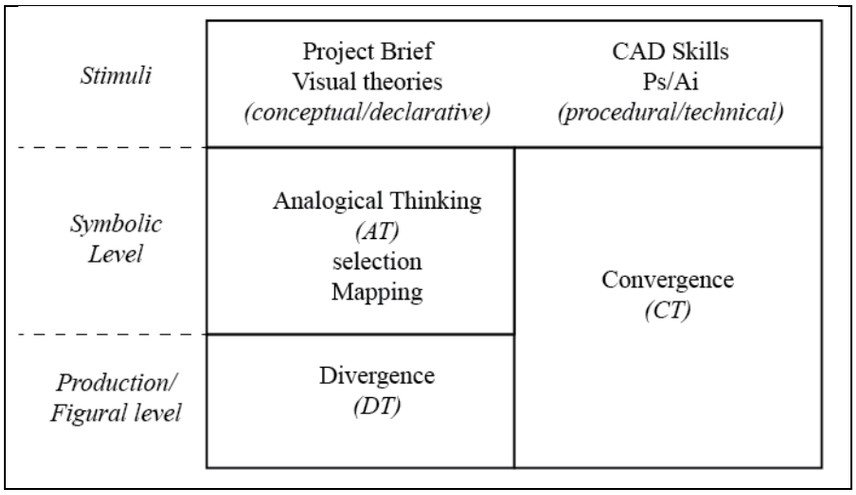

FIGURE 3. The basic framing of this study. This article aims to describe how these processes are related to one another

METHOD

PHENOMENOLOGY

It is essential as well to note that thinking is a subjective experience. In broader terms, thinking happens when we are inclined to do something that benefits our well-being (Heidegger 2004: 3). And as each person are capable of unique ideas, the inclinations of the use of CAD systems varies. Reaction to problems is different from person to person, and in turn require different technical implementations. But what is certain is that most designers will experience thinking, and therefore understanding the Creative Design Process with CAD can be made through exposure of this experience and its essences.

As an iterative process (Brown 2008), the chaotic process of Design, such as the cycle of ideation, implementation and evaluation shows that it is unfitting for a quantitative approach. Moreover, the study of creativity with Design is relatively under explored if compared to other contexts such as innovation and in organizations (Williams et al. 2016). In addition, it tends to put greater emphasis on quantitative methods (Long 2014). Influenced by positivism, quantitative studies posits that knowledge exists outside of the subjective experience which then ignores the subjective and nuanced human factors (Lincoln & Guba 1985, 2013), such as the various ways of how designers think creatively

Hence, this study employed a qualitative approach with the adoption of the Descriptive Phenomenological method (Giorgi 2015). Moustakas (1994: 13) explain that the phenomenological approach "*involves the return to experience in order to obtain comprehensive descriptions*" in which these experiences become the basis for analysis. Langdridge (2007: 5) describes that Phenomenology aims "*to study experience and how the world appears to people*" and therefore employs methods that "*elicit rich descriptions of concrete experiences*".

PARTICIPANTS

Participants are selected purposively. Up to seven undergraduate students from a Graphic Design course of a Public University in Malaysia are recruited at the time this study is conducted. Undergraduates are selected as they are within the transition of 'formal apprenticeship' from novices to professionals (Kaufman & Beghetto 2009). This phase of creative development provides access to the phenomena in various circumstances as it is a stage of experimentation and the honing of skills. This ensure that rich data are elicited from the participants. The data collection process is prolonged for two (2) to four (4) hours each day within a six-day period.

DESIGN PROJECTS

Data are elicited by the participants through three projects. Each of these projects requires the participant to produce visual representations at different levels of restrictions. These projects have allowed the phenomena to be accessed through various situations. And thus ensured that the phenomena of the creative experience are adequately engaged. All of the design process are screen-recorded on the computer.

Project 1: participants are told to design visuals that represent a Malay proverb. Ten listed proverbs are given to the participants. Among them are '*kacang melupakan kulit*', '*indah khabar dari rupa*', '*perah otak*' and others. Participants are free to choose which of the idioms that they are interested in working on. The proverbs are the only restrictions for this project.

Project 2: participant is told to create visuals that represent meanings from texts found in popular media, such as lyrics of a song, movie lines or quotes and phrases from creative writing such as novels or poetry. Popular media carries specific contexts that the participant needs to conform to during the process of creating visuals. Participants are allowed to choose texts from media that are personal to them. Therefore, participants have greater freedom in this project and any restrictions are self-imposed.

Project 3: participants are told to create visuals for a musical album. Participants are required to conform towards specific objectives such as the size of the artwork, and the use of a layout to compose texts and pictures. Proper visual treatment gives relevant representation for the album's artists and will show how restrictions affect the design process and subsequently, their thinking. The restriction in this project is relatively higher than the previous two.

DATA COLLECTION METHODS

This study employed verbal reporting techniques (Ericsson & Simon 1980) namely *the think-aloud* (Charters 2003) and the *stimulated recall* with *screen-recordings* (Calderhead 1981). Think-aloud are employed concurrently with a creative design task and allow the closest exposure to the experience when it occurred. For this technique, probes are conducted concurrently with the design process. The stimulated recall is used after significant visual elaborations has been made. During this procedure, the investigator simultaneously probed the participants along with a review of their design process that had been screen-recorded. The probes are mostly retrospective. This allowed the participants to reflect on their feelings or experience during the design process. All of the probes are audio-recorded and transcribed. Afterwards, each data sets of the participants are summarized and retold during member-checks to ensure credibility and confirmability. The summarization, transcriptions and screen recordings are triangulated during analysis.

RESULTS

All of the data sets are *horizonalized,* and 231 meaning units are identified. Through imaginative variation, these meaning units are interrogated and revealed seven themes that are experienced during the Creative Design Process.

THEME 1: THE EXPERIENCE OF PRODUCING IDEAS THROUGH CONCEPTS

Especially during the early stages of creative Design, the participant benefits from personal knowledge and experience to produce ideas. Relevant knowledge is conveyed and expressed through words such as 'typography', 'readability', 'cubism', 'surrealism' and 'pop-art' as an inspiration. These words are directly related to knowledge commonly used in Graphic Design. Along with knowledge, this study finds that past observations are also used as an inspiration. For instance, Symbols drawn from popular media are expressed through words such as 'slender-man' and 'anime character'; which are concepts that appear in tv shows and video games. This indicate that it is sourced from memory, and are accumulated overtime through personal observations towards popular media. The range of inspiration from established knowledge to personal experiences shows the random nature of idea production. Figure 4 is an example of the use of 'surrealism' as a concept to convey visual representation.

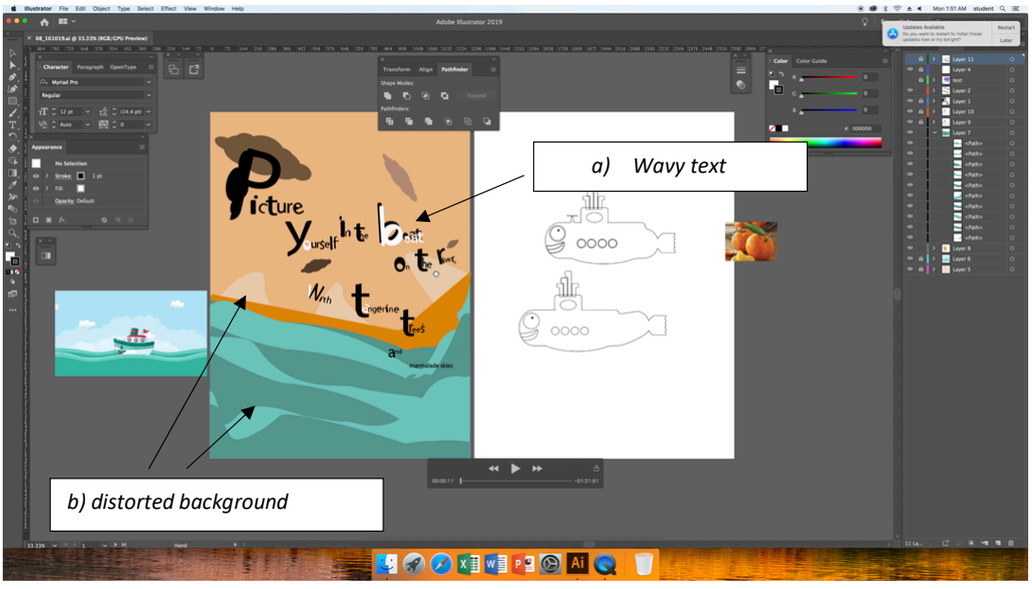

FIGURE 4. Ideas produced from the concept surrealism through the (a) wavy text, and b) distorted background.

THEME 2: THE EXPERIENCE OF PRODUCING IDEAS THROUGH CONCEPTS AND SKILLS

At the symbolic level, ideas are produced through the combination of concepts. This includes abstract understanding of specific techniques. This show that learned skills can become one of the concepts that the participant uses along with existing ones. Occurring at a symbolic level means that it can happen independently from elaboration. The combination of concepts and skills might lead to two extremes; they either support or undermine the ability to produce new ideas. And this depends on how direct the relations or inclinations between concepts and technique. In other words, concepts and procedures must be isomorphic to support the production of ideas and any incompatibility can undermine or prematurely abrupt the creation of ideas. Figure 5 is an example where the feature 'brush' in Ps is used in various ways as it is understood at a symbolic level. This opens up the possibility of 'brush' to be used consistently with ideas found in several elements such as visual imagery and texts.

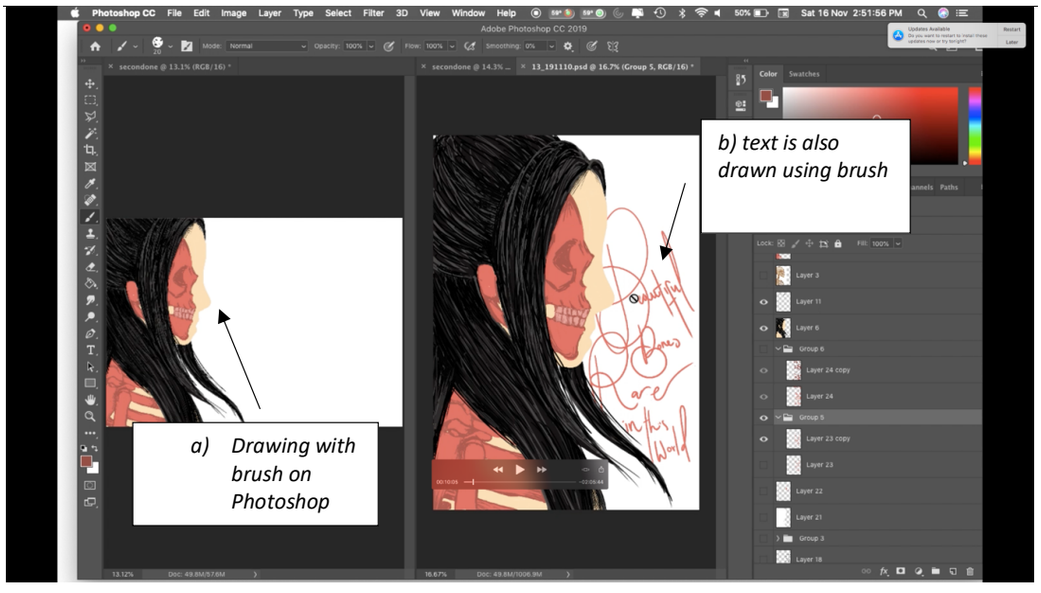

FIGURE 5. Ideas produced through skills such as brush in (a) and (b)

THEME 3: THE EXPERIENCE OF ELABORATING IDEASBASED ON CONCEPTS AND SKILLS

The CAD system is used to elaborate ideas to visual representations. It is a space where all of the designs are experimented and brought forward to completion. As discussed before, at a symbolic level, ideas can occur through the combination of concepts and skills. In other words, it is within elaboration that the participant discovers either their symbolic combinations do go as expected. The abandonment of produced ideas can happen if skills failed to deliver expected outcomes. And this shows that prior combinations of concepts and technique at the symbolic level are evaluated inadequately. As CAD systems allow ideas to be easily tested, it diminished the need to evaluate its appropriateness. It is usually after ideas are elaborated that mishaps are realized. This led the participant to either adapt or pursue the same approach by finding other technical skills. At times, current tasks are abandoned to start anew. Figure 6 and 7 show how one participant abandon an elaboration strategy and approach a new one by substituting technical skills.

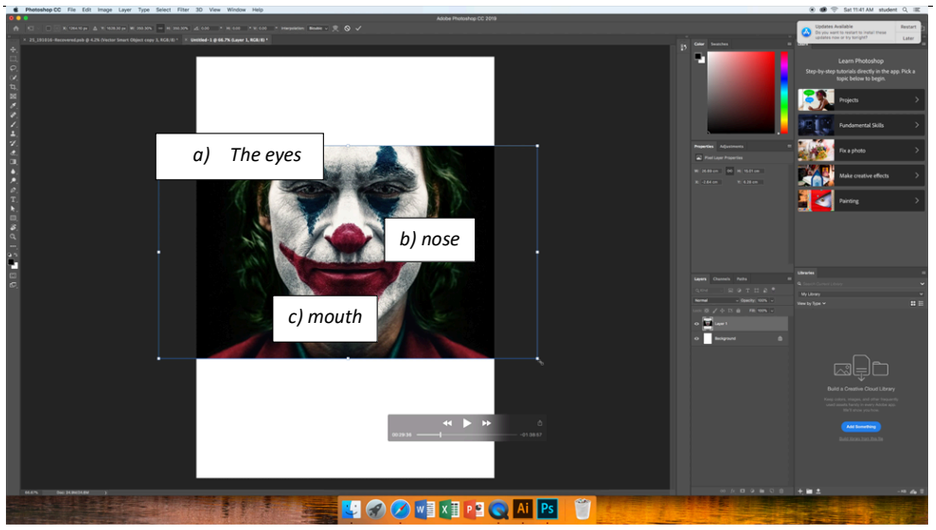

FIGURE 6. Concepts drawn from an internet image source. The absorbing of concepts is through a) the eyes, b) nose, and c) mouth.

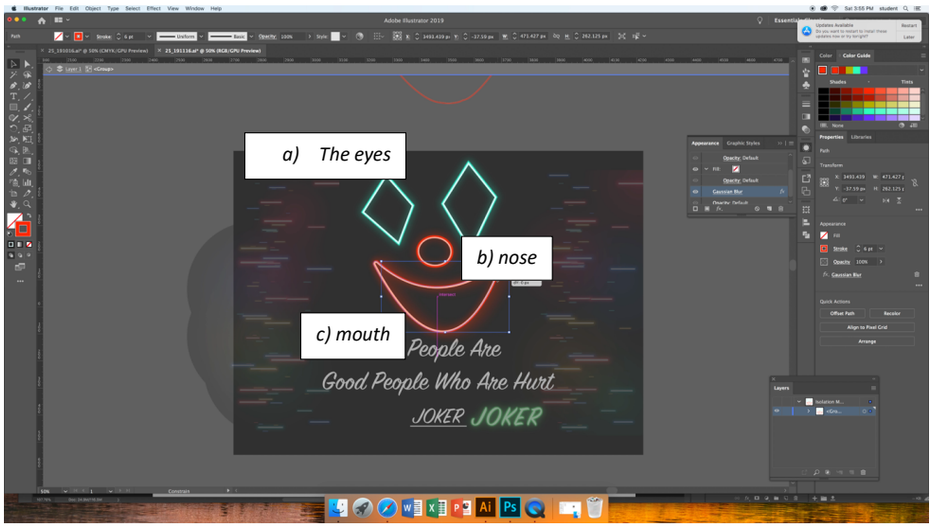

FIGURE 7. the undesired result of implementing concept (a, b, c) from Figure 3

THEME 4: THE EXPERIENCE OF ELABORATING IDEAS THROUGH SKILLS

Some instances showed minimal use of concepts due to the abundant features the CAD system provide. In this way, technical skills dominate the production of ideas as the combination with or among concepts are somewhat limited or absent. The strategy to find solutions, therefore, is per what the CAD can provide. Technical skills on the other end are limited to only what the participant know or have learnt. At times, this hinders conceptual expansion and led to the desertion of current task because of the lack of techniques as outlet for ideas. If technical skills dominate within this context, elaboration often backtracks such as restarting projects by shifting to other CAD systems or the change of visual reference. In some cases, the lack of technical skills in this context replaces current elaboration methods and strategies to favour an efficient one especially when it is realized that the task requires two or more procedures to execute. Figure 8 shows how one participant used images sourced from the internet instead of creating new ones as it requires more steps and techniques and thus inefficient. Figure 9 shows how elaboration is improved mainly by technical skills. When technical skills are learned ("double exposure"), it allows concepts to be used to evaluate appropriateness. Like in the example given, participants manage to create a seamless composition that consists of images and texts. However, the degree of originality is in question since images used are ready-made.

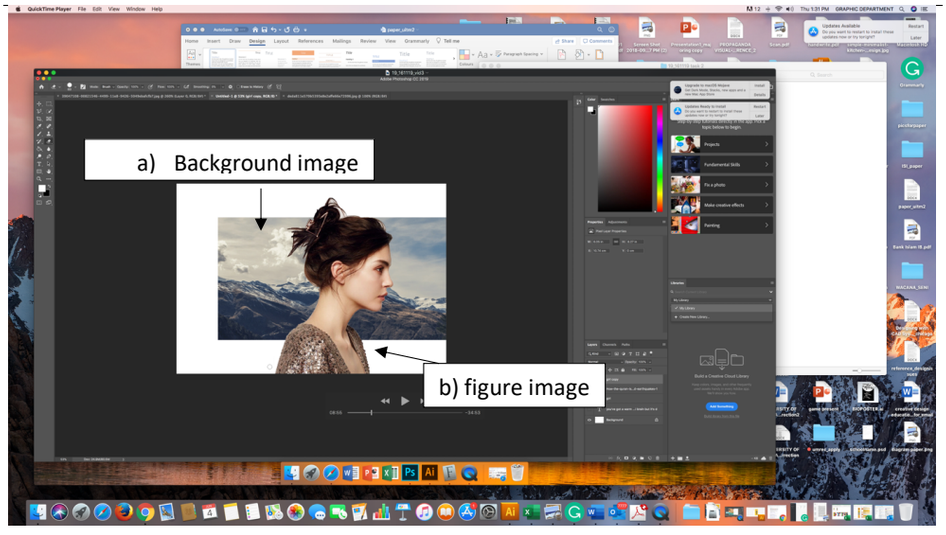

FIGURE 8. The use of internet image (a,b) to substitute the producing ofnew image creation.

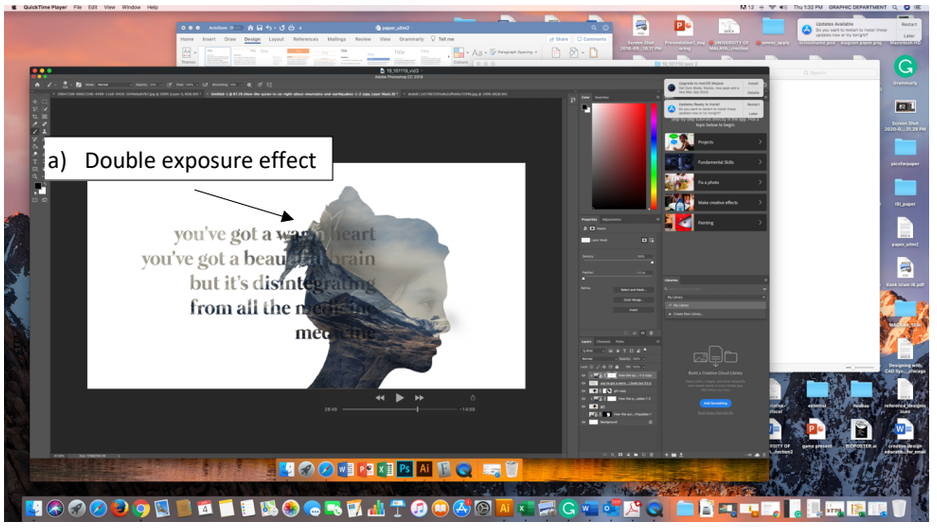

FIGURE 9. Although elaborated through the use of a particular technique(a), the image used is not original

THEME 5: THE EXPERIENCE OF APPROPRIATING IDEAS THROUGH LEARNING

The flaws of combinations between concepts and technical skills can offer an opportunity to learn. In many instances, the failure to elaborate encourage learning. Previous theme has shown how a participant used images from the internet. Others have used the internet to understand lyrics of a song, the mood of a song through observing music videos and learning new skills through video tutorials such as 'double exposure'. The internet in some ways provides opportunity among the participant to re-evaluate concepts and skills in different perspectives. Sources from the internet become cues or used as a reference. Figure 10 is an example of a participant learning 'double exposure'.

There are indications that the process of creative Design becomes a process of editing pictures rather than producing visuals. Learning is encouraged either by the urge to solve technical difficulties or to expand ideas. And this is shown through the use of the internet to find images that is easier to edit. The participants seemed to know images that had certain properties and its corresponding features in CAD. For instance, an image in figure 8 is selected from the internet because it had a plain coloured background, and therefore allowed the '*auto-selection tool*' in Ps to easily crop to only leave the figure image. This is to fulfil the requirements of the newly learned 'double exposure' technique. While new skills are learned, it also encourages the use of ready-made images as the criteria for certain techniques parameterized the kinds of images required. However, search results do not always conform to this. This phenomenon is one of the contributing factors of premature abandonment of ideas.

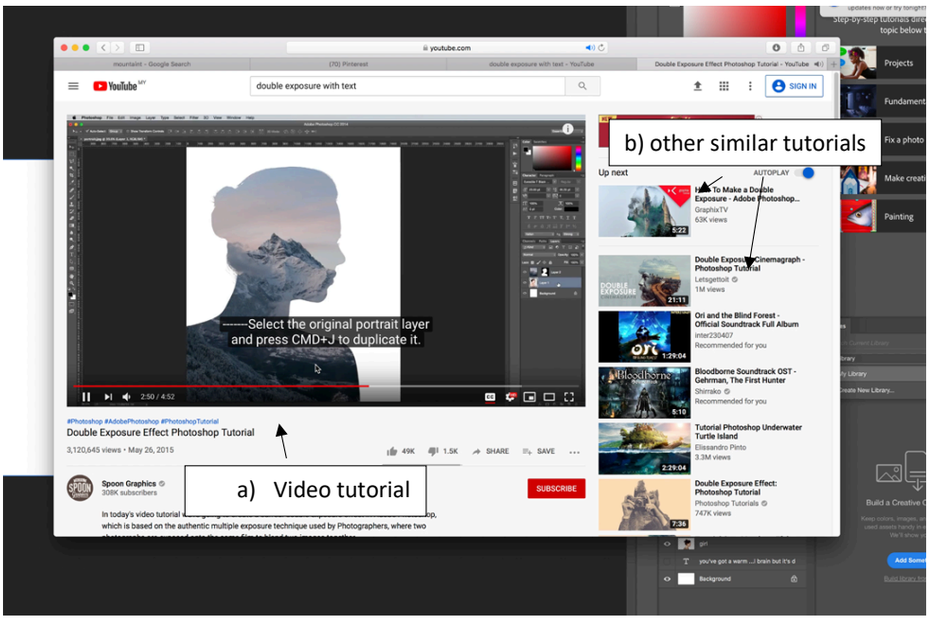

FIGURE 10. The internet provides various sources (a, b) to learn.

Appropriating ideas seems to relate to the breadth of knowledge that a participant has. Depths in knowledge recalls greater number of previous concepts, experience and techniques to restructure weak combinations. Furthermore, it increases the evaluation of sources so that more concepts become relatable. Participants also shows openness in learning new concepts from various graphic design movements such as '*Swiss design*' and '*Russian propaganda posters*' and other artworks by expert practitioners through internet technology. These sources add more layers to the combination of ideas, and at times is used to even-out the lack of technical skills. This approach to learning augments existing skills, and to a certain extent, becomes more adventurous in using unknown features to test and experiment. Learning, especially concepts is an essential element of the experience whereby it helps leverage the dominance of an overly technical approach.

THEME 6: THE EXPERIENCE OF CLOSURES THROUGH THE EVALUATION OF CONCEPTS

Ideas require proper closures. A milestone or a specific benchmark is needed as a rule to tell the participants either certain aspects for completion is fulfilled or requires more attention. When ideas and elaboration is completed and conform to the benchmark, ideas are concluded or proper ideational closure is attained. The result of elaboration is interpreted into symbolic representation in the mind and subsequently used to compare with the context of the project. For instance, affirming ideas is met through its appropriateness with contexts that is near to the artwork. For example, the visual treatment of an artwork with the 'minimalist' style (Figure 11), is similar and benchmarked to the 'minimalist' interface of the digital music platform 'Spotify' (Figure 12).

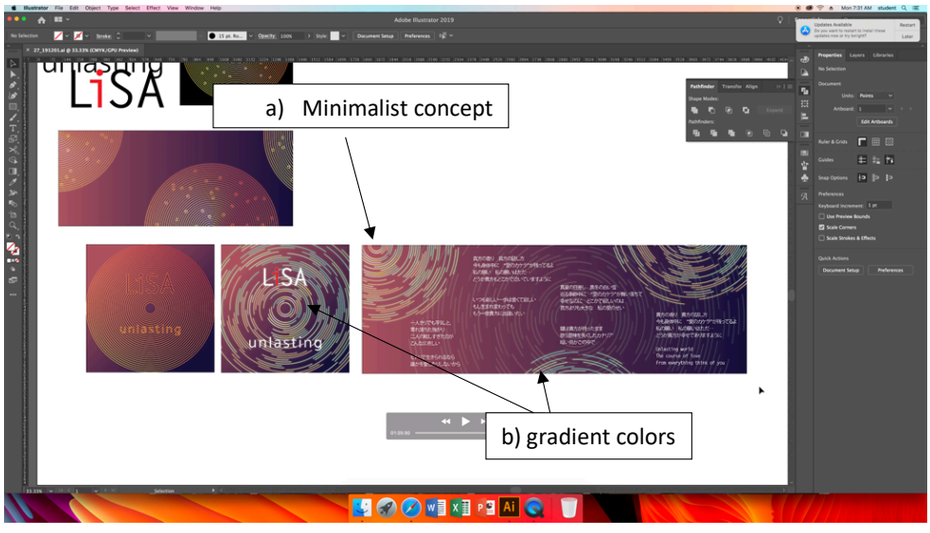

FIGURE 11. The concept of a) minimalism and the use of b) gradient colours is applied.

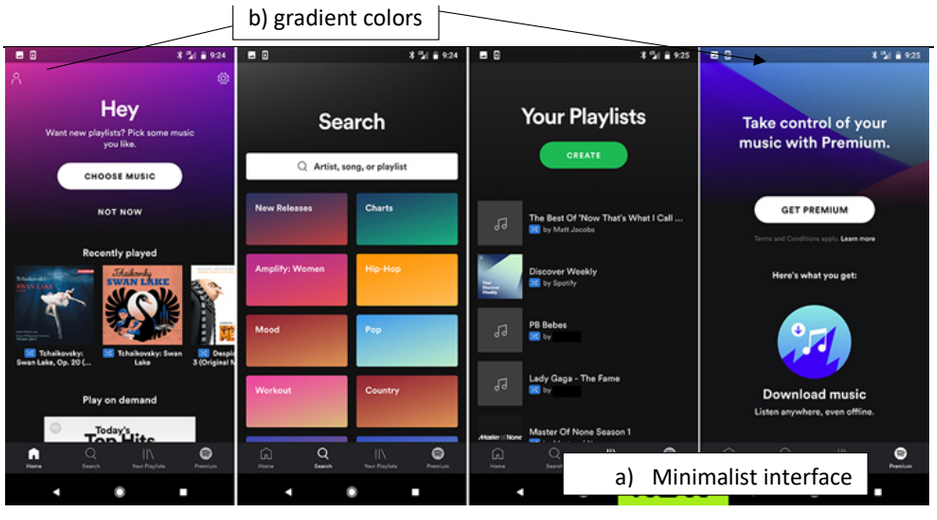

FIGURE 12. The concept in Figure 8 is based on the concept drawn from the app "Spotify" (a, b). (Image source: https://community.spotify.com, n.d)

On the other end, when ideas did not find proper closures, the process can divert its attention towards other tasks such as the postponement of current elaborations to focus on other elements in the artwork when concepts contradict. Abandoning task is usually after all of the visual elements are evaluated.

More depths in specific knowledge allows the mind to navigate within the problem space, seeking other characteristics that is plausible to be used. In this instance, ideas are preserved for completion and at times led to idea or conceptual expansion. On the contrary, the lack of knowledge provides a narrow space for the mind to navigate. And thus, the concept is prematurely abandoned without any attempts to expand it.

THEME 7: THE EXPERIENCE OF IDEATIONAL CLOSURE BASED ON THE EVALUATION OF EXISTING SKILLS

Ideational closures can also be based on the consideration of existing skills. Ideas are selected and closed based on the participants capability to elaborate on the CAD system. This usually happen when ideas are freely combined with other concepts at the symbolic level and increases its complexity. Thus, it becomes too troublesome to implement as it leads to many procedures. Some participants who often suffers from this experience tend to neglect ideas to favor a straightforward approach as it is more efficient with existing technical skills. The lack of expertise at times led to search for existing CAD files on the internet that are editable. For instance, some participants opted to search for files that is available on *freepik* (https://www.freepik.com). Sources of this kind provides ready-made visual elements and provide a quick solution to certain elements. Regarding this behavior, this study cannot conclude the nature of this type of media that is encouraged by an open-source attitude are ethically an opposite stance to the strive for originality. The participants seem to perceive it as a common trait within the online community. This is outside of the scope of this study and therefore an interesting area of concern for future studies.

In many instances, the internet is oftenly used to seek easier solutions and alternatives. This led to the use of existing images or artwork, which in succession carries foreign concepts with no intended meanings. Moreover, it seems that the difference is subtle between using the internet to find inspiration and finding easier solutions. Ideational closure that is reliant on technical skills that is believed to guarantee an easier approach to design is undesirable. It has the potential to turn the creative design process to a mere problem-solving strategy. Although completion still can be achieved, it can also lead to premature results.

DISCUSSION

This study finds that domain and relevant knowledge is paramount and therefore agree with current suggestions and concern on the development of procedural and declarative knowledge in educational contexts (Plucker et al. 2021). The themes show that the Creative Design Process with CAD is influenced by concepts and technical skills as it allows the interpretation of information and enables strategies for elaboration. These two components are vital as it can influence the creative design process and as symbolic inputs for the operation of AT which in turn affects DT and CT responses. This finding is consistent with a previous model that suggests knowledge as a component in creative cognition (Runco & Chand 1995). Knowledge, either conceptual or technical becomes inputs in ideation. The depth of expertise determines either ideation suffers from fixation or further elaboration. The discussion onwards discusses how knowledge components namely skills on CAD influence the internal processes of ideation that contains the process of DT, CT and AT. The descriptions are explained through the scenarios of 1) the necessary ideation processes with the CAD system and 2) learning to find and seek more ideas and solutions for further elaboration.

IDEATION WITH CAD

Knowledge components that include concepts and technical skills affect the continuum of DT and CT by at first going through the process of identifying similarities between concepts and technical expertise through AT. Identifying similarities at first goes through the phase of selection in the structures of

these two knowledge. the sub structures between this two knowledge are later mapped based on similarity. For instance, principles from the concept of '*pop-art*' are listed out; such as the use of '*humor*', '*satire*' and '*contrast of colors*'. Concurrently, technical knowledge listed out its sub concepts, such as '*vector graphics*', '*bitmap graphics*', '*illustration*', or specific functions available in CAD systems such as '*brush tool*', '*quick selection tool*', '*pathfinder*' and others. Afterwards, AT will progress through the process of mapping in which these sub-concepts of knowledge is fused based on complementary criteria. And this is how ideas are produced through concepts and technical skills which subsequently results in planned elaboration (see Figure 13). For instance, if 'contrast of colors' is complementary to 'illustration' and 'bitmap graphics', it will lead to the use of Ps as it is primarily a software that processes bitmap images. This is the stage where solutions, strategies and plans for elaboration in the selected CAD system are formed

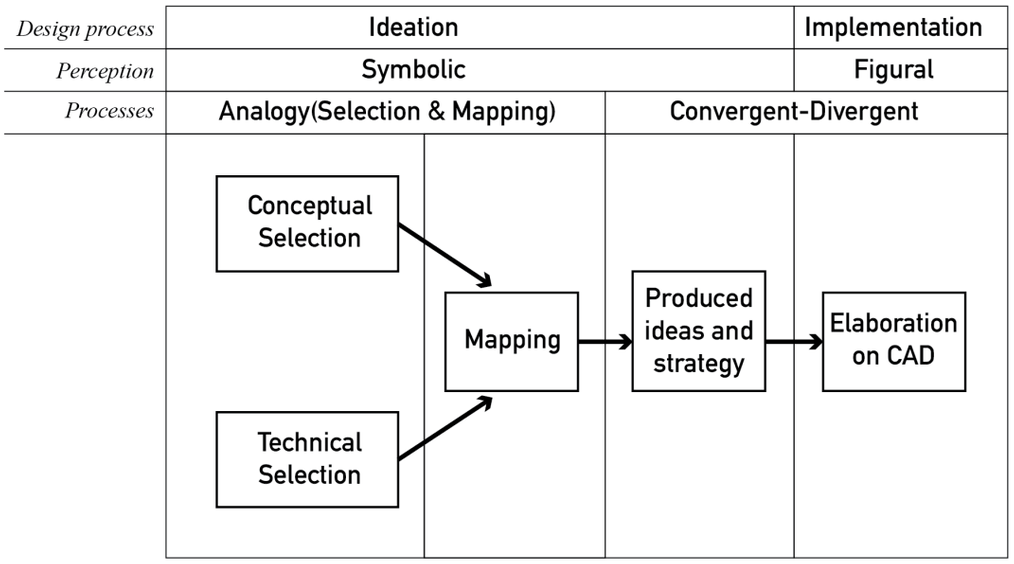

FIGURE 13. How ideas are produced from Conceptual and Technical Knowledge and Stimulate AT and DT

The influence of knowledge in whatever form is noteworthy. Greater depth of knowledge will provide more criteria selection; especially conceptual or declarative knowledge which can be utilized to categorize information (Kirkhart 2010). In a sense, it expands the space for fusing and combining ideas and thus stimulate DT leading to the production of various solutions. The more depth the knowledge presents, the more likely mappings will occur and thus encourage original ideas (see figure 14). Other than ideation, the deeper depths of knowledge provide the evaluation between concepts which led to proper closures through CT. In other words, breadth of knowledge stimulates AT and greatly influence CT especially in deciding optimal solutions. Perhaps this is the link between CT and knowledge (Cropley 2006). And this, in turn, increases the formation of appropriate ideas and at the same time, increase the selection of proper tools and features found in CAD systems. CT is also used to predict the type of strategies to use. Productivity measures such as the time needed for completion, the complexities and the kinds of treatments necessary to sustain ideas from going beyond its intended meaning, are some of the strategies elicited by the participants.

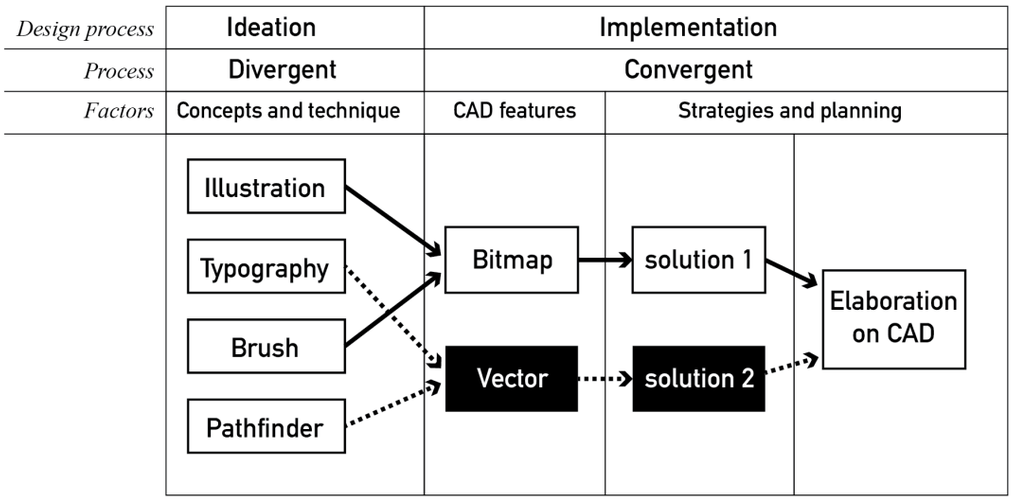

FIGURE 14. How CAD features dictate the types of concepts and techniques to be used. The dotted lines represent if Concepts and techniques related to 'Vector' processing is available to produce alternative solutions.

As Gestalt psychologist have previously claimed that perceiving visuals corresponds to meaningful experience and the existence of *pragnanz*, which is a psychological phenomenon where visuals are instinctively corrected to its simplest form (Arnheim 1974). For instance, we often see how an artist creates a painting that corresponds to what he had experience and seen and seem effortless in doing it without major alterations. This is true if declarative and procedural knowledge is expansive in AT based on the findings. However, this study also finds that selection and mapping process of AT does not always guarantee desired results when it is greatly or solely influenced by technical or procedural knowledge. This might be because the selection and mapping process of AT is constrained towards satisfying goals such as efficiency. In one instance, Ps is selected because it is a trusted tool as the experience using it led the analogist to believe that it will make the task easier. This constrained AT to select, and map based on this static and pragmatic notion (Spellman & Holyoak 1996). Therefore, the process will be anchored to this purpose instead of original ideas that stems from conceptual knowledge, which is used to understand the relationship of visual elements (McCormick 1997).

LEARNING AS PART OF THE CREATIVE PROCESS

However, in some cases, ideation is disrupted when concepts or technical skills is minimal; nevertheless, reflections can stimulate learning processes. In a way, learning is a strategy to find solutions and a typical feature of AT which act as a reconciliation mechanism when two concepts fail to map and combine (Holyoak & Thagard 1995). When learning activates, it seeks relevant information, such as using the internet which provides useful information and expands the space of knowledge. And consequently, build more schemas or structures in which its sub-concepts can be selected for mapping processes (Figure 15).

Furthermore, the CAD system mostly used in this study (Ai and Ps), provides plenty of features and therefore stimulate exploration towards unlearned technical skills. This is perhaps due to the effectiveness of its interface. However, this requires more support from other research. Even so, the abundance of feature increases experimentation and gives more shape to an idea. In this way, learning facilitates the expansion of ideas and encourage skills development in implementation. This explains the relation of AT with DT responses.

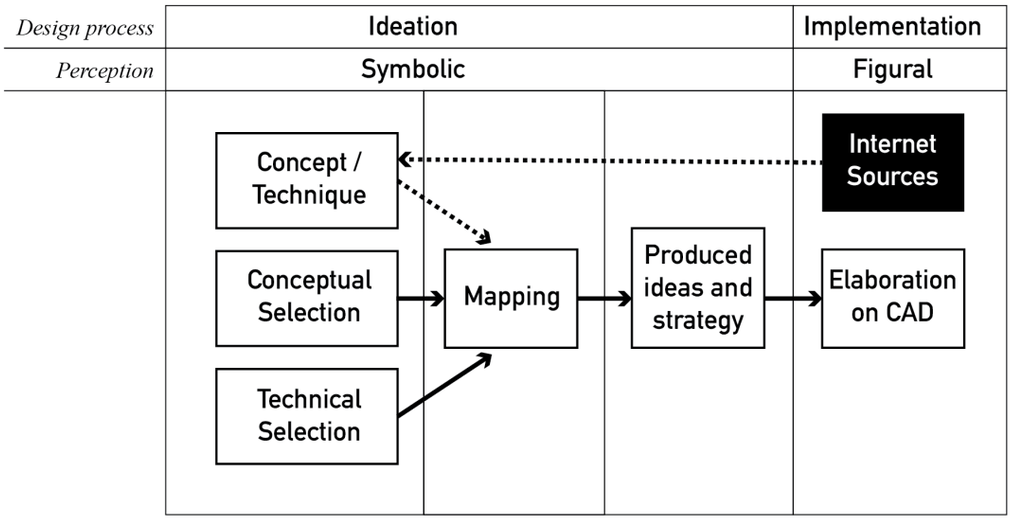

FIGURE 15. Learning occurs in implementation due to the easiness to find learning materials on the internet. Learned concepts becomes a symbolic structure that can be analogize and mapped for ideas.

CONCLUSION

This study shed some light on the creative process of Graphic Design with CAD. The description of AT, DT and CT can inform instructors or educators on how students think and its relation to their approach in design. Perhaps the findings presented can be used creatively by educators in classrooms, as the nurturing of creative and innovative mindset can be supported by creative teaching (Jariah et al. 2020). Moreover, one study has concluded that project-based learning that is often associated with the Graphic Design curricula, must encourage the use of technology (Nik Narimah et al. 2020). Findings from this study shows how CAD systems are approached, its relation to ideas and the knowledge involved is significant in identifying encouragement efforts. Another study reports that knowledge and skills on technology is perceived to be insignificant among undergraduates from public universities in Malaysia (Nor Hazwani & Sheerad 2020). As the findings of this study have shown, using technology creatively can contribute to the development of new artefacts which is advantageous in an economy that strives on innovation. Perhaps, this study might give new definition towards technology among undergraduates and thus contribute to their prospects and self-efficacy.

This study is limited to the context of Graphic Design and CAD. Therefore, there are other aspects of creative Design that this article did not highlight, such as social cultural values of the environment (peers, tutors, industrial experts) and how its influence in nurturing creativity. Another aspect that is worthwhile to investigate is how certain personality types affect the creative design process with CAD as certain traits such as learning in AT are approached differently among the participants. As this study is limited to creative process, other aspects of creativity such as *Product*, *Press* and *Personality* (Rhodes 1961) adds more depth to the explanation of Creative Design with CAD.

Finally, this paper only covers the use of CAD to produce visual representation. There are other ways in which CAD or other platforms of digital technologies support the creation of other kinds of products, which in turn provides a different type of connections to Creative Design (Lubart 2005, Magner 2017). For instance, interest in software that enables the capacity for coding or programming is growing. The ability to code or computer programming carries the qualities of other domains such as physics and mathematics that are still foreign to creative design. It will be an exciting area of study to observe the combination of these types of knowledge during the Creative Design activity based on the relationship of AT, DT an CT.

REFERENCES

Alipour, L. 2020. Computer-aided design tools and creativity, *sid.ir*. https://www.sid.ir/FileServer/SE/659E20200101. Retrieved on: 20 June 2021

Alipour, L., Faizi, M., Moradi, A., & Akrami, G. 2017. The impact of designers' goals on design-by-analogy. *Design Studies* 51(C):1-24.

Arnheim, R. 1974. *Art and Visual Perception: A Psychology of the Creative Eye.* Berkeley, California: University of California Press.

Ayman-Nolley, S. 2010. A Piagetian perspective on the dialectic process of creativity. *Creativity Research Journal* 12(4): 267-275.

Bailey, J. 2020. The tools of generative art, from flash to neural networks, art in America. https://www.artnews.com/art-in-america/features/generative-art-tools-flash-processing-neural-networks-1202674657/?fbclid=IwAR0fz-BpnnrLJu0-9fpMBZ_tt8jdPoKILJGldjjZ6WY96Kn69_Q0vAmLX9M. Retrieved on: 8 January 2020

Bonnardel, N., & Zenasni, F. 2010. The impact of technology on creativity in design: An enhancement? *Creativity and Innovation Management* 19(2): 180-191.

Brown, P. 2009. CAD: Do computers aid the design process after all. *Intersect* 2(1): 52-66.

Brown, T. 2008. Design Thinking, Harvard Business Review. https://hbr.org/2008/06/design-thinking. Retrieved on: 20 June 2021

Calderhead, J. 1981. Stimulated recall: A method for research on teaching. *British Journal of Educational Psychology* 51: 211-217.

Charters, E. 2003. The use of think-aloud methods in qualitative research: An introduction to think-aloud methods. *Brock Education Journal* 12(2): 68-82.

Cropley, A. 2006. In praise of convergent thinking. *Creativity Research Journal* 18(3): 391-404.

Cross, N. 1982. Designerly ways of knowing. *Design Studies* 3(4): 221-227.

Cubukcu, E., & Cetintahra, G. E. 2010. Does analogical reasoning with visual clues affect novice and experienced design student's creativity? *Creativity Research Journal* 22(3): 337-344.

Dahl, D. W., & Moreau, P. 2002. The influence and value of analogical thinking during new product ideation. *Journal of Marketing Research* 39(1): 47-60.

Ericsson, A. K., & Simon, H. A. 1980. Verbal reports as data. *Psychological Review* 87(3): 215-251.

Fasko, D. 2006. Creative thinking and reasoning: Can you have one without the other. In *Creativity and Reason in Cognitive Development*, edited by Kaufman, J. & Baer, J, 159-176. Cambridge: Cambridge University Press.

Feenberg, A. 2017. A critical theory of technology. In *Handbook of Science and Technology Studies*, edited by Felt, U., Fouche, R., Miller, C.A. & Smith-Doer, L., 635-663. Cambridge, Massachusettes: MIT Press.

Gick, M. L., & Holyoak, K. J. 1983. Schema induction and analogical transfer. *Cognitive Psychology* 15: 1-38.

Giorgi, A. 2015. *The Descriptive Phenomenological Method in Psychology*. 6th edition. Pitssburgh, Pennsylvania: Duquesne University Press.

Goldschmidt, G. 2014. *Linkography: Unfolding the Design Process*. Cambridge, Massachusetts: The MIT Press.

Goldschmidt, G. 2016. Linkographic evidence for concurrent divergent and convergent thinking in creative design. *Creativity Research Journal* 28(2): 115-122.

Guilford, J. 1956. The structure of intellect. *Psychological Bulletin* 53(4): 267-293.

Heidegger, M. 1977. *The Questions Concerning Technology and Other Essays.* (W. Lovitt, Trans.) New York: Harper Perennial.

Heidegger, M. 2004. *What is Called Thinking?* (J. G. Gray, Trans.) New York: Harper Perennial.

Holyoak, K. J., & Thagard, P. 1995. *Mental Leaps: Analogy in Creative thought.* Cambridge, Massachusetts: The MIT Press.

Jariah, M. J., Siti Zaidah, Z., Azlin Zaiti, Z., Sheena, K., & Roshidah, H. 2020. New academia learning innovations in University Malaya. *Akademika* 90 (Special Issue 2): 117-127.

Jiajun, G., Islam, A. Y., Teo, T., & Spector, J. M. 2019. Computer-enabled visual creativity: an empirically-based model with implications for learning and instruction. *Instructional Science* 47(5): 609-625. doi:https://doi.org/10.1007/s11251-019-09487-0

Kanisauskas, S. 2016. Creative technologies entrapped by instrumental mind. *Filosofija sociologija* 27(1): 40-50.

Kaufman, J. C., & Beghetto, R. A. 2009. Beyond big and little: The four C model of Creativity. *Review of General Psychology* 13(1): 1-12.

Kirkhart, M. 2010. The nature of declarative and nondeclarative knowledge for implicit and explicit learning. *The Journal of General Psychology* 128(4): 447-461.

Langdridge, D. 2007. *Phenomenological Psychology: Theory, Research and Method.* Essex: Pearson Education Limited.

Laurillard, D. 1982. Applying educational research to design education. *Design Studies* 3(4): 193-195.

Lawson, B. 2002. CAD and creativity: Does the computer really help? *Leonardo* 35(3): 327-331.

Lincoln, Y. S., & Guba, E. G. 1985. *Naturalistic Inquiry.* Newbury Park, California: SAGE Publications, Inc.

Lincoln, Y. S., & Guba, E. G. 2013. *The Constructivist Credo.* Walnut Creek, CA: Left Coast Press, Inc.

Long, H. 2014. An Empirical review of research methodologies and methods in creativity studies (2003-2012). *Creativity Research Journal* 26(4): 427-438.

Lubart, T. 2005. How can computers be partners in the creative process: Classification and commentary on the Special Issue. *International Journal of Human-Computer studies* 63: 365-369.

Lupton, E., & Phillips, J. C. 2015. *Graphic Design: The New Basics*. 2nd edition. NY: Princeton Architectural Press.

Magner, T. F. 2017. Technology and creativity. In *Creativity & Innovation: Theory, Research and Practice*, edited by Plucker, J.A, 277-294. Waco, Texas: Prufrock Press Inc.

Marcuse, H. 1964. *One Dimensional Man.* London: Routledge.

McCormick, R. 1997. Conceptual and procedural knowledge. *International Journal of Technology and Design Education* 7: 141-159.

Moore, G. E. 2015. Progress in Digital Integrated Electronics, IEEE Milestones Wiki. http://ieeemilestones.ethw.org/images/5/5e/Moore_1975_IEEE_Speech.pdf. Retrieved on: 4 January 2020,

Moustakas, C. 1994. *Phenomenological Research Methods.* Thousand Oaks: SAGE Publications.

Nik Narimah, N. A., Nurfaradilla, M. N., Muhammad Helmi, N., & Juritah, M. 2020. Needs analysis for the development of cross-cultural corporate identity curriculum model for graphic design programme. *Akademika* 90 (Special Issue 3): 189-201.

Nor Hazwani, H., & Sheerad, S. 2020. Work readiness skills, self-efficacy, enterepreneurial behavior and career exploration among graduates. *Akademika* 90 (Special Issue 3): 155-165.

Paul, C. 2008. *Digital Art : Revised and Expanded Edition.* New York: Thames & Hudson world of art.

Plucker, J., Mcwilliams, J., & Guo, J. 2021. Smart contexts for 21st century talent development. In *Conceptions of Giftedness and Talent* edited by Sternberg, R. & Ambrose, D., 295-316. Palgrave Macmillan.

Rhodes, M. 1961. An analysis of creativity. *The Phi Delta Kappan* 42(7): 305-310.

Robertson, B. F., & Radcliffe, D. F. 2009. Impact of CAD tools on creative problem solving in engineering design. *Computer-Aided Design* 41: 136-146.

Runco, M. A. 2008. Commentary: Divergent thinking is not synonymous with creativity. *Psychology of Aesthetics, Creativity, and the Arts* 2(2): 93-96.

Runco, M. A., & Acar, S. 2012. Divergent thinking as an indicator of creative potential. *Creativity Research Journal* 24(1): 66-75.

Runco, M. A., & Chand, I. 1995. Cognition and creativity. *Educational Psychology Review* 7(3): 243-267.

Runco, M. A., & Jaeger, G. J. 2012. The standard definition of creativity. *Creativity Research Journal* 24(1): 92-96

Schweitzer, F., & Robert, M. 2021. The double-edged word of intricate idea enactment in product development. *Journal of Business Research* 132: 392-402. doi:10.1016/j.jbusres.2021.04.054.

Shih, Y., & Sher, W. 2021. Exploring the role of CAD and its application in design education. *Computer-Aided Design and Applications* 18(6): 1410-1424. doi:https://doi.org/10.14733/cadaps.2021.1410-1424

Spellman, B., & Holyoak, K. 1996. Pragmatics in analogical mapping. *Cognitive Psychology* 31(1): 307-346.

Williams, R., Runco, M. A., & Berlow, E. 2016. Mapping the themes, impact, and cohesion of creativity research over the last 25 years. *Creativity Research Journal* 28(4): 385-394.

Mohd Hafnidzam Adzmi (Corresponding Author)
College of Creative Arts
Universiti Teknologi Mara
Puncak Alam Campus
42300 Bandar PuncakAlam,
Selangor, Malaysia
Email: mohdh013@uitm.edu.my

Zahari Ishak
Faculty of Social Sciences & Liberal Arts
UCSI University
No. 1, Jalan Menara Gading
UCSI Heights (Taman Connaught)
Cheras
56000 Kuala Lumpur
Malaysia
Email: zahari@ucsiuniversity.edu.my

Che Aleha Ladin
Department of Educational Foundations and Humanities
Faculty of Education
University of Malaya
50603 Kuala Lumpur
Malaysia
Email: chealeha@um.edu.my

Received: 26 june 2020
Accepted: 2 July 2022