

**Exploring an Alternative Pedagogy of Digital Know-how and Know-why:
New Media Art Curation as a Solution**

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Summary

The significance of computational thinking and/or digital literacy is attracting more and more scrutiny from researchers, educators and practitioners in all fields, from the discipline of science to psychology, and from computer science to art. Yet, unfortunately, there is still a lack of profound methodologies of education and assessments for the development of digital know-how and know-why. (Ekstrom et al., 2017; Malinverni, 2014; Knochel and Patton, 2015; Good, Keenan and Mishra, 2016) That said, increasing interdisciplinary research as well as practices is expanding the possibilities in HCI and CSI education. It is important to create an environment that supports and facilitates the development of digital know-how and know-why publicly, and encourage critical thinking and lifelong learning in this hypermediated era.

The research is based on reviewing materials including articles, journals, research papers, reports and books related to Computer Science Educations and the power dynamic of Human-Computer Interactions (HCI). Hence, the corresponding pedagogies are compared to the reception of New Media Art.

Through closely examining the diverse current pedagogical practices and educational theories for computer science, the prevailing beliefs and design aspects are found to be aligned with the interactions with New Media Art. Hence, by presenting new media art as a tool for deep-understanding of digital technology, assisted by appropriate curatorial practices, the exhibition space is turned into a co-learning environment to inform and inspire the public with regard to the subject matter in focus.

Table of Contents

Abbreviations.....	1
1. Introduction.....	2
2. Theoretical Foundation	2
1. Space, Knowledge and Power.....	2
1. Digital devices as physical objects	2
2. Digital devices as Abstract Machines	4
2. Different Facets of Digital Know-how and Know-why.....	6
1. Digital Literacy	6
2. Computational Thinking	6
3. Computational Literacy	7
4. Procedural Literacy	8
5. Algorithmic Skill	9
6. Section Summary	9
3. HCI today.....	10
1. The Power Dynamic in HCI	10
2. Limitation(s) of the current HCI conditions	11
1. Shallow Interactions with Graphic User Interface.....	11
2. Natural-User Interface is Not Natural.....	12
3. Limitations in Digital Literacy: Operating != Understanding	15
4. Conventional Computer Science/ Informatics (CSI) Education	17
1. Current CSI Pedagogy	17
2. Problems and Concerns.....	19
3. Proposed Solution: Constructivist Approach and Bodily Engagement	23

1. Constructivist Approach.....	23
2. Bodily Engagement.....	26
5. Computing and Aesthetics	31
1. Aesthetic Understandings for Science Educations	31
2. Art and Computational Thinking	34
6. New Media Arts as an Alternative Pedagogy	36
1. Nature of New Media Art	36
1. History and Definition	36
2. Aesthetic in the Procedural Processes.....	37
3. Embodied Interactions	38
4. Active Cognitive Engagement derived from Physical Interactions	40
5. Media Art as the Art Making Experience	42
2. Experiencing Media Art in the Museum Context	45
1. Open-ended Space	45
2. The Museum Experience as An Experience	47
7. Conclusion: Is Curatorial Practice for the Alternative Pedagogy a Dilemma?....	49
Bibliography	52

Abbreviations

HCI:	Human-Computer Interactions
CSI:	Computer Science and Informatics
ICT:	Information and Communication Technology
GUI:	Graphic User Interface
NUI:	Natural-User Interface
FUBILEs:	Full-body Interaction Learning Environments

1. Introduction

While the discussion on the potentials and numerous implementations of HCI is still under debate, this paper aims to provide a new perspective on the power of interdisciplinary practices. Hence, it is hoped to encourage individuals to realize their capabilities, and positively begin to engage with knowledge from another discipline.

The paper consists of seven chapters. The first and the last chapters are the introduction and the conclusion respectively, the other chapters are allocated to reflect the thought-development of the research process. Chapter 2 provides the theoretical foundation on the understanding of power-dynamics, with reference to the ideas from philosophers such as Michel Foucault, Henri Lefebvre, Gilles Deleuze and Félix Guattari. Chapter 3 deconstructs the prevailing current situations of Human-Computer Interactions (HCI), followed by an analysis of the conventional education models of computer science and informatics (CSI) in chapter 4. Hence, from realizing the possibilities in introducing art education in CSI, chapter 5, explores the idea of computational aesthetics. The idea is then associated with the experience of art appreciation and art engagements. Thus, chapter 6 provides details of the argument by juxtaposing the discussed pedagogic practices and philosophies with the characteristics of New Media Art.

2. Theoretical Foundation

1. Space, Knowledge and Power

1. Digital devices as physical objects

In discussion of Foucault's philosophy on technology, Jim Gerrie (2003) describes, "Foucault's reflections on power uniquely parallel a position accepted by a significant

segment of philosophers of technology, that is that technology is not simply an ethically natural set of artifacts by which we exercise power over nature, but also always a set of structured forms of action by which we also inevitably exercise power over ourselves.” For Foucault, power is both generated from within and exerted from the environment, whilst the environment is often a result of one’s utilization of technology and take of actions.

Henri Lefebvre’s depiction on the role of space also suggests its significance in shaping our knowledge and cognition. With reference to *The Production of Space*, Lefebvre stated that “*Even if the links between these concepts and the physical realities to which they correspond are not always clearly established, we do know that such links exist, and that the concepts or theories they imply— energy, space, time— can be neither conflated nor separated from one another.*” (1991, p.12) The physical objects are embodied with a set of ideas and concepts of how we perceive the world, and thus advocates how we react to things.

In this sense, the presence of digital media fundamentally manipulates the (physical) space as a tactile device. Hence, similar to how stones and branches inspired the development of Stone Age toolkits, media devices suggest to us new ways to behave and interact with the environment. John Carey and Martin C. J. Elton gave a great example of the influence of technology on our behavior in their book *When Media Are New: Understanding the Dynamics of New Media Adoption and Use*, “As a technology is adopted, it often leads to lasting changes in user behavior: for example, the remote control led to more changing of channels.” (2010, p.155) Hence, the media devices’ impact on the interactions between media devices and our behavior does not only stop at this level. Indeed, it begins a sequential effect and facilitates changes

in/form the environment in response to one's adopted action. Just as they continued with the example, the increased changing of channel eventually resulted in a change in the structure of broadcasting: more segmentation of programs with constantly emphasized indication of the channel names.

The essence/significance of educating the skill of technological know-how is thus akin to that Henri highlighted in *The Production of Space*, it “does not aim to produce a (or the) discourse on space, but rather to expose the actual production of space by bringing the various kinds of space and the modalities of their genesis together within a single theory.” (1991, p.16)

By making explicit how a space, and even how a device or a machine, is put into place, the environment shall by itself suggest the connectivity and inter-relations of its contained object.

2. Digital devices as Abstract Machines

As we are able to understand digital devices as mechanisms which deliver certain mindsets and frame our behavior, we can easily extend this logic and conceive that digital devices are therefore also assemblies of abstract concepts.

With reference to Asja Szafraniec, those devices are machinic assemblage of components which are defined by their capacity for channeling or interpreting a flow. Hence, it is a given set of “conceptual configuration” (2011, p.485) that alters or shapes our perspectives in a pre-defined way.

Borrowing Deleuze and Guattari's philosophy on matters, since the assemblage "are affected by coefficients which take stock of the assemblages' potentialities, creativity, according to the way in which they complete (that idea)" (1984, p.16), a digital device therefore functions as an abstract machine, or to be exact, an abstract concept of a machine. Along these lines, human perceptions are to be understood as the primarily source of power and control which completes the flow of Human-Computer Interaction (HCI). The human perception operates just like a machine: with the counterpart with a digital device as the input, then the process of understanding the device's capacity, and the person finally attains the output of operating the device (as in action). Meanwhile, digital devices are mechanic systems which are dependent on human input — they would not function without a "deterritorialization" triggered by a physical articulation.

That said, although at a glance, human perception seems to be the fundamental origin, and thence the core of power and control, it is important to note that the enclosed set of concepts would be perceived differently based on the user's previous knowledge and experiences. One of the most widely discussed examples would be the difference between "digital natives" and "digital immigrants".

Defined by Marc Prensky (2001), "digital natives" refers to the generation which had grown up with intensive use of digital tools such as the television, computers, video games, cell phones and the Internet; whilst the older generation who are enchanted by, and adopted such new technologies are referred to as the "digital immigrants". Thus, he pointed out that as a result of such change of the environment, "today's students think and process information fundamentally differently from their predecessors". Consequently, it is important to revise the conventional mode of teaching and learning,

and cater to an adapted pedagogical environment that matches with the new thinking pattern. (Turner and Hicks, 2013) The details of the shift in thinking patterns influenced by different HCI interfaces will be discussed in Chapter 2.

2. Different Facets of Digital Know-how and Know-why

Before proceeding to a further discussion on pedagogy design for digital know-how and know-why, it is essential to first develop a general understanding of the different facets of the topic:

1. Digital Literacy

Paul Gilster (1998) illustrated the idea of digital literacy with a primarily focus on the ability to retrieve appropriate information from the Internet. According to the author, the World Wide Web enables great interactivity, and therefore the users are able to navigate through different contents in their own will and own pace. Hence, mastering this digital tool (the Internet) means to understand its archival structure, as well as to select valuable information from the vast contexts. Similarly, other scholars also associated digital literacy with the technical skill of performing tasks on computers, assisted with the cognitive and sociological skill to sort out useful information. (Inoue et al., 1997; Eshet-Alkalai, 2004; Lenham, 1995; Lankshear and Knobel, 2008, pp.18-24)

2. Computational Thinking

Computational Thinking is a theoretical framework proposed by Jeannette M. Wing to

shed light on the advocacy of popularizing the abstract thinking skills of computer scientists for the general public. Borrowing Wing's sentence, "Computational thinking involves solving problems, designing systems, and understanding human behavior, by drawing on the concepts fundamental to computer science." (2006)

In another article published in 2008, Wing further elaborated the concept of computational thinking as a complex, high-level thinking process of abstraction. For instance, apart from algorithmic thinking and parallel thinking, the thought process also features the employment of compositional reasoning, pattern matching, procedural thinking and recursive thinking. Respectively, it is suggested that through matching the thought process with the capacity of the computer, one can better understand the limitations and power of the computational tool. As a result, one would be able to apply or develop apt strategies or knowledge to achieve the desired outcome.

Thence, in short, the term depicts the process of understanding computational functions, as well as reflecting on the correlation of oneself and the contingency of the computer. In a broader term, computational thinking can be understood as the problem-solving approach with the utilization of computers.

3. Computational Literacy

Computational Literacy is a term long existed before education researcher Andrea A. diSessa proposed the critical definition of the term in 2001. According to diSessa, computational literacy refers to the ability of implementing computational tools as an aid to achieving various goals upon the understanding of the computational formalism.

It is complementary to the idea of computational thinking, that the distinction between computational thinking and computational literacy is laid on the difference on their emphasis. The accent here is on the enacting of computational knowledge such as programming languages as the mean of problem-solving. While in contrast, as mentioned earlier, the term computational thinking focuses primarily on the problem-solving thought process developed in compliance with the operation of a computational device. (diSessa, 2018)

4. Procedural Literacy

Initially proposed by B. A. Sheil (1980), procedural literacy highlights the significance of both educators and the students to develop deep structural understanding of programming skills. Moreover, it encourages people outside the professional field of computer science or engineering to author software to tackle real world problems.

The idea is further elaborated by Ian Bogost in 2005, for which he pointed out that procedural literacy should not be confined only to issues related to computer science. Thus, with reference to Wise and Bauer's concept of "interrelatedness of knowledge", Bogost wrote: "engendering true procedural literacy means creating multiple opportunities for learners – children and adults – to understand and experiment with reconfigurations of basic building blocks of all kinds". (p.36)

Under this thinking, procedural literacy is not restricted to the knowledge in coding or computer science engineering, but rather it should be a structured way of seeing the system, and disciplined thinking of the process behind.

5. Algorithmic Skill

Generally speaking, algorithmic skill refers to the proficiency of applying programming concepts, such as short-term memory and the process of recursion, when developing software or handling informatics. In other words, a person with higher algorithmic skill are better in recognizing and developing networked, structured and regulated information as knowledge. (Pushkin, 1998)

This idea is often applied in the study of learning experiences. It is adopted as a crucial assessment of how well the knowledge is delivered, by analyzing how the knowledge is memorized and reproduced by the student. (Biró et al., 2016) Moreover, by comparing the conceptual model of the Turing Machine with human computational activities, algorithmic skill is also identified to be a crucial element of our cognition. (Giunti and Pinna, 2016)

6. Section Summary

Despite the difference of the focus in the terminologies above, the proposed concepts all feature attentions on the following aspects:

Firstly, the understanding of the systemic structure of digital media;

Second, the ability to implement the corresponding knowledge in real-life situations.

In this fashion, we might conclude that the nuance of various ‘digital literacy’ educations is aimed to develop the know-how and know-why of digital medias.

3. HCI today

1. The Power Dynamic in HCI

While digital media offers us a new way of experiencing the world- with hyper connectivity from between individual to societies and cultures, the extensive permeation of digital media in our everyday life has also hindered our understanding of self and power. This is because, during the process of interacting with a digital media, we devote our action as an extension of our body without realizing the disconnection of it with the digital outcome. As the action is shadowed and received by the medium, the action is, however *encoded* as a set of data. Hence, the representative set of data becomes detached from our actual body, for which we are not able to fully comprehend the information without assistance by the digital media to resemble the prior action.

Human-Computer Interactions (HCI) had long been a substantial field of interest to researchers – both in academia and industry – for its uncharted possibilities and potential in social, scientific and economic activities. While the studies in interface design remarkably facilitated the growth of new technologies (Myers, 1998), there is an increasing diversion in the research focus with little unity. In contrast with the ‘pure scientific’ perspective which focuses on the functionality and the computational process of hardware and software interfaces, HCI also attracted scholars and researchers from the art and humanity background. One example of these would be the activity theory, a research framework that was first proposed in the 1920s. Under this research framework, researchers highlight the mental and physical needs of interacting with computers in everyday practices It suggests that “consciousness is not a set of discrete disembodied cognitive acts ... and certainly it is not the brain; rather,

consciousness is located in everyday practice”. (Nardi, 2001, p.7) Hence, alike Marshall McLuhan’s view that the medium is the message (1973), activity theorists also identify HCI as an attachment of the world, rather than “merely filters or channels through which experience is carried”. (Nardi, 2001, p.10) Along these lines, computer interfaces can be understood not only as a mean to deliver its embodied schema, but also as a mechanism that directly shapes one’s sensibility and experience.

2. Limitation(s) of the current HCI conditions

1. Shallow Interactions with Graphic User Interface

According to the findings from Mária Csernoch and Piroska Biró, Graphic User Interfaces (GUI) fosters users to commence trial-and-error solutions because “they do not understand and are not interested in the message provided by the software”. (2015, p.552)

This is because human perception and cognition are built upon the theory of Representationism. (O’Neil, 2008, p.29) When a computer function (the abstract concept) is represented by a proximal visual simulation, merely the final outcome of the represented function or the external object involved in the corresponding conceptual process is revealed to the user, but not the algorithmic function itself. For example, in most computer systems and software, the action to delete files or prior operations are represented by an icon of a rubbish bin; and the action to magnify elements are pictured with the icon of a magnifier. Such representations are indirect and separated from the actual function. In other words, whilst the user is able to obtain the computational result, the mechanism is encapsulated and withdrawn from the user.

Even though by conveying complex computer functions with simple icons, often accompanied with straight-forward descriptions, GUI had greatly improved the understandability of computer systems for which it requires only little prior experience or knowledge to operate the device. Accordingly, GUI facilitates the ever-growing popularity of computers. (Hillstrom, 2005, p.15) Yet, as the visual elements signify only the outcome of function but not the process itself, GUI indeed hinders users from developing deep understanding of the capability of the device, and therefore, also from developing the ability of critical employment of such devices.

2. Natural-User Interface is Not Natural

Since Natural User Interface (NUI) was introduced, operation of computers had generally become more intuitive. Consequently, the computational processes are often hidden away from users.

According to Totaro and Ninno, algorithmic systems can be classified into two types. The first type, which they called the “time-space distancing systems” (2014, p.42), features a “physical distancing of the subjects of interaction”, but in the same time it restores the interactions on the distanced plane (Harvey, 2000; Giddens, 2015). On the other hand, the second type of algorithmic systems physically distance subjects, and force the interaction to “abandon the plane of communication to connect them according to the formal rules of a process.” (Totaro & Ninno, 2014, p.43) Hence, it does not provide any replacement of the interaction (Crozier 1999), and therefore the interaction cannot be traced back from the computational outcome. This type of system is referred to as “systems of logical distancing”, and it is associated with “the

encapsulation of action within algorithmic steps”. (Totaro & Ninno, 2014, p.43)

The above concept helps draw attention to the shift of power dynamics in HCI from Command Line Interface (CLI), Graphic User Interface (GUI) to NUI. With CLI and GUI, the mechanism can only respond to specific ‘point-to-point’ actions, which a user must make the effort to learn what are the possible actions, and remember how it can be evoked. (Norman, 2010) For example, a user must type in a precise command to execute an action; or, a user must rely on a device such as a mouse to perform actions by pointing to and/or clicking on different portions of the screen. (Maidment, 1997, p.23-6) In both ways, the computers interpret the command action according to the current context, and it is only able to perform commands accordingly. This is because the available commands and the corresponding responses are stored in a database, and the users must learn and explicitly execute the commands. Accordingly, a user must be aware of the passivity of the device, and be all the time conscious of the capability of the computer.

As the possibility of the interactions is explicitly represented with command codes and visual elements, the computational outcome is directly associated in sequence with the user’s action. Hence, it is possible for users to easily identify the exact actions taken in result of the outcome. In this sense, CLI and GUI can be understood as “time-space distancing systems”, for which they allow users to restore the procedural interactions simply by tracing the steps involved.

Yet, with NUI, although commands and responses are also stored in a database, it is important to note that the input taken here is interpreted as a set of data, before it is processed and modelled as a command. NUI functions based on multimodal

recognition-based system, and it is designed to be adaptive to the users' movements and gestures. (Oviatt & Cohen, 2000; Myers, Hudson and Paush, 2000) Taking Kinect as an example, the body movement and its position is represented by a set of skeletal data. The human body and its actions are transformed into a figurative set of data, and it is the data, but not the body itself, that activates commands and enables interactions. In David M. Rieder's article, it is mentioned that "once we deterritorialize the origin of those points, we can experiment, developing new types of bodily gesture and movement contributing to a new canon of digital delivery. And once a user's movements and position are redefined radically, the environmental feedback from the projected movements has the potential to transform how that user experiences herself, which can lead to new, counterhegemonic experiences of self." (2013) This highlights the substantial objectivity of NUI: once the recognition algorithm is altered, the same body movement and gesture would convey a different connotation, and thus result in a different outcome. The connection between the response and the action is not mutual. Besides, NUI is designed to be "seamless" and "intuitive". As one of the design principles of NUI, Daniel Wigdor and Dennis Wixon suggested that natural user experience can be designed "by creating an environment that leads users to suspend their sense of disbelief, no longer comparing their actions to a defined pattern, and experience a direct connection between their actions and the objects and operations of the system." (2011, p.43) Hence, it means that with NUI, users interact through learning how their body relates to the recognition system, without realizing the resemblance of their body as a set of reference data. This makes NUI a "system of logical distancing", and to such a degree, it suppresses one's power over their bodily practices.

With reference to Anna Munster, "computers offer us multiplications and extensions

of our bodily actions... These multiplications by no means provide seamless matches between body and code; the mismatch characteristics of divergent series triggers the extension of our corporeality out toward our informatic counterparts... It is this extensive vector that draws embodiment away from its historical capture within a notion that the body is a bounded interiority.” (2006, p.33)

3. Limitations in Digital Literacy: Operating != Understanding

1. Heidegger’s Philosophy on “Being”

The isolation of consciousness from the operation of digital devices can be further addressed with Heidegger’s philosophy of ‘being’. (2010) In his philosophy, being is both physically perceived from senses in everyday practices, and consciously aware of one’s existence in the world. The elemental way of being is the being-as-itself, or in other words, to appear as the way it is. For example, think of a stool in front. The stool exists physically in the world as: a plane placed horizontally, with four vertical poles evenly attached beneath it. Then, by seeing such form of an object, we associate it with the abstract idea of a stool which we learnt from our everyday practice, and therefore we interact with the ‘stool’ accordingly (for instance to sit on it). This would be ‘being-as-itself’. Here, despite the presence of the ‘stool’ is registered in our interactions with such, the existence of the ‘stool’ is not questioned. Hence, we do not perceive or ‘think’ about the object’s existence as in relation to our being. In Heidegger’s words, these two states of being was referred to as ‘ready-to-hand’ and ‘present-at-hand’ respectively.

The contrast between the two state-of-mind mentioned above echoes with the core discussion of this paper: that is, interactions with digital devices does not necessarily

guarantee the understanding of the device. As Shaleph O’Neil reflected on this subject in his book *Interactive Media: The Semiotics of Embodied Interaction*, our primary encounter and disclosure of the environment is built “through our embodied interaction with the physical matter that constitutes it”. (2008, p.35) Hence, we perceived the world by its physicality. However, the mental awareness of the environment, such as the possible capacity of an object, is often omitted.

2. Affordances

Proposed by James J. Gibson, the term ‘affordance’ bears the idea that “the values and meanings of things in the environment can be directly perceived”, as such value and meanings are “external to the perceiver”. (1986)

The idea is comparable to Heidegger’s philosophy on existence, for which both authors depict the realness of the world based on our perceptions of the world’s physical attributes. Similarly, both doctrines imply that our consciousness is primitively embodied within the objects and the environment, until we become aware of the characteristics of object itself. Thus, in order to become conscious about nature of the object, one must ponder the capability of the object while reflecting on its relation to oneself.

Henceforth, along with the studies of the limitations in user-interface designs discussed earlier, those philosophies address clearly the dilemma of Human-Computer Interactions. Following the above concepts, the physical attributes of objects predominantly determine our perception of the world. Yet, even if the ascendancy of the materialness of digital devices are inevitable, seeing the impact of physical

attributes on our cognition helps to design emancipatory interaction experiences.

4. Conventional Computer Science/ Informatics (CSI) Education

1. Current CSI Pedagogy

In a study on the development of deep-learning approaches of CSI education, scholars blamed its deficiency on its monopolized characteristic. (Csernoch and Biró, 2015)

While the major development of CSI technologies is led by a few ‘tech giants’, such as IBM, Apple and Microsoft, the core intent of providing computer machines and software was to improve productivities. By the end of 1980s, computers are appreciated for its capability to store and retrieve information more than the algorithmic computing technology itself. On account of this shift of attentions, the word ‘computer’ is placed with the term ‘information technology’ (IT). (Pelgrum and Law, 2013, p.19) In addition, since e-mails became popular in the early 1990s, computer technologies are then recognized as the ‘Information and Communication Technology (ICT)’. This change in terminology indicates societies’ emphasis on the socioeconomic benefits of computers, more than the abstract process of computing.

In the article *Who Needs Computers in Schools, and Why?*, David Hawkridge (1990) had comprehensively discussed the role of computers in education, and outlined the four rationales for using computers in schools, namely:

- 1- The social rationale, which advocates the significance of “computer awareness” for becoming a responsible and knowledgeable citizen;
- 2- The vocational rationale, which highlights the indispensable need of ICT skills for future employments;
- 3- The pedagogic rationale addressing the potential of ICT as an assisting tool

for education of other subjects; and

- 4- The catalytic rationale that supports changes in educational innovations, and even the power structure in schools and classrooms

Although the competence to emancipation and self- empowerment is revealed in early studies of ICT integration in education, current curriculum developments world-wide are primarily built upon social and economic drives. (Tondeur et al., 2007)

As a matter of fact, the importance of ICT education is associated with life skill development and employment preparation under the Sustainable Development Goals (SDGs). As it is outlined in SDG Target 4.4: “By 2030, substantially increase the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs and entrepreneurship”. (Pelgrum and Law, 2016, p.4) Consequently, information processing and document-creating skills are widely-integrated in most school curriculums as an aid to improve learning experiences. (UNESCO, 2009, pp.12-3; Tondeur, 2008; Tikoria and Agariya, 2017) Because of the above reason, most CSI pedagogy across various countries tend to focus on the practical application of digital media. (Lubin, 2016; Fluck et al., 2016; Wilson, Scalise and Gochyyev, 2015) In other words, ICT courses often feature skill-based curriculums, and the knowledge of the procedural operation behind the digital tools are often omitted.

According to research (Sturman and Sizmur, 2011), students in countries such as Japan, Singapore, Italy, USA (Massachusetts) and Canada (Ontario) are required to create spreadsheets and/or presentations with sound and images for subjects other than the ICT class. Meanwhile, curriculum content in computing generally counts for

the technical knowledge such as basic terminologies and the name of computer parts, keyboard skills, as well as the concepts of hardware and software; not to mention the use of World-Wide Web and emails. Particularly for the case of Japan, studies of computer technology in elementary to secondary schooling are predominantly textbook-based, and is aimed to develop students' understanding of computer based on "*knowing about the technical aspects*". (p.9) Although basic computing skills to programming are introduced to students from between 12 to 16 years old across the reviewed countries/regions, assessments are often task-based and encourage little creativity of the students. (p.7)

2. Problems and Concerns

Although the need for empowering generations with digital literacy is discussed extensively since 1980s, the implementation of related education schemes and pedagogies are still under debate. (Costa, 2016; OECD, 2015) Moreover, markets and industry are concerned with the shortage of labor with proficient digital skills. (Duggan, 2013; Anicic, Divjak and Arbanas, 2017) For instance, according to the publication by the European Commission in 2015, it is estimated that there will be around 500,000 unfilled ICT vacancies by 2020. On the other hand, researches have also identified the deficiency of current CSI education models. With reference to Katz and Macklin (2013), instruction-guided learning experiences in computer labs discourages student engagements, and therefore hinders students' problem-solving and critical thinking ability. (Katz and Macklin, 2007; Livingstone, 2012) In another study on digital literacy assessment in the USA, it was found that almost 72% of the students have failed the assessment, according to the traditional assessment scale. (Murray and Pérez, 2014)

The information reflects on the fact that despite efforts being put into developing digital literacy of young generations since an early age, the systems failed to equip students with adequate computer skills. (Hilberg, 2008) Subsequently, current CSI pedagogy are incapable of raising student's interest in computing.

Unfortunately, the problem is not only an obstacle in the young generation's learning experience. It also challenges the quality of teacher developments and supports.

(Goode, Margolis and Chapman, 2014; Porter et al., 2017)

The emphasis on the socioeconomic capacity of computers draws an impact on the model of teacher trainings in a likely manner. According to the scholars, most teacher education institutes only offers one computer course with mere focus on practical ICT skills (Hsu and Sharma, 2006) Although fundamental knowledge of CSI is taught as part of the teacher preparation, such technical skills are insufficient for encouraging teachers to integrate computer technology in lessons as an aid to critical thinking.

(Albion, 1999; Mishra, Koehler and Kereluik, 2009; Lawless and Pellegrino, 2007)

The unsatisfactory acquisition of computer skills from the classroom-contexts is believed to be a result of various human factors, apart from material obstacles such as lack of computers and/or software, as well as lack of space. According to a research conducted by W. J. Pelgrum across 24 countries (2001, p.173), 66% of respondents identified teachers' lack of ICT knowledge and skills to be the major problem in achieving ICT-related educational goals. Besides, 51% of the respondents identified a lack of technical assistance; along with 31% associated the issue with the low quality of teacher training, and 19% of them addressing the lack of administrative assistance. In such a way, due to a lack of profound knowledge in CSI, teachers and institutions

are facing hard times delivering computational knowledges as critical skills, but technical practices.

Moreover, since the computer technologies are ever-changing, the demand for CSI education is placed under high pressure. Hence, it restrains the educators from having sufficient time to acquire deep understanding of the regarding contents before entering the classrooms. Meanwhile, curriculums with technical focus become outdated easy. This made it extremely difficult for educators to develop effective pedagogy for development of digital know-how and know-why. (Greening, 2000; UNESCO, 2009, pp.8-11; Nawaz and Kundi, 2010; Sentence and Csizmadia, 2016)

As educators and institutions fail to design pedagogy and school curriculums in a long-term basis, CSI education became a paradoxical situation. Henceforth, it thereby leads to an inconsistency in education emphasis and objectives.

The condition is even worsened by the absence of direct predecessors of the subject matter. Computer science is still a young field of studies with limited reference on education and assessment methodologies. Hence, although more and more researchers, educators and institutions are associating CSI with the field of science and engineering (thus derived the term ‘computer science’), the alignment between those fields are never officially recognized until recent years. (Buckler, Koperski and Loveland, 2018, p.15; Costa, 2016, p.437) In fact, with reference to Edgar W. Jenkins, technological education should instead to be considered as a stand-alone subject. As he noted, “in seeking this broader and potentially more secure place for technology within education, some professional technologists have argued for technological activity as a distinct 'third culture', to be added to the arts and the sciences as a

component of a liberal education.” (Jenkins, 1998)

Hereafter in 2015, the U.S. Congress passed the STEM (science, technology, engineering and mathematics) Education Act of 2015 to include computer science as part of the scientific discipline. Soon after that, in January 2016, President Obama announced the “Computer Science for All” initiative policy which encouraged schools to include computer science courses as an individual elective. (Guzdial and Morrison, 2016)

Yet, although there had been a drastic increase in the number of computer science courses offered in schools and colleges, we must acknowledge the fact that educators are not prepared for such changes. In 2006, researcher Joseph J. Ekstrom and his colleagues published a paper to shed light on the concern of the lack of “the advantage of an existing model for guidance” when starting college computer science courses. Now, more than 10 years later, researchers (Guzdial and Morrison, 2016) still find CSI courses unable to support the educational need of computer science in the current knowledge-based society. In addition, it is even identified that students, parents and principals as yet have misunderstandings on what computer science study is about. (Markauskaite, 2006; Hewnwe, 2013; Roseman et al., 2017)

Whilst new CSI pedagogic approaches for young generations are still being discussed and tested, scholars are also suggesting various methods of teacher training for the transforming education need of computer science. Despite so, there is no consolidated assessment method for the corresponding learning outcome. For this reason, the effectiveness of either of education models cannot be monitored. As scholars and researchers struggle to analyze the pros and cons of the ongoing adaptations (Robins,

2015; Butler et al., 2016; Wiggins et al., 2016; Buckler, 2018; Porter et al., 2017), computer technology continues to advance expeditiously. The ratified models therefore easily become outdated, or distracted from its original objective.

On the other hand, the unsatisfactory results of our current CSI pedagogies also lead to a lack of professionals of the field. Hence, it is likely to further hinder the improvement of CSI educations as well as the development of digital know-how and know-why. (Almstrum, 2005; Roberts, 2016)

3. Proposed Solution: Constructivist Approach and Bodily Engagement

1. Constructivist Approach

Constructivism is a theory of knowledge and learning. In contrast to objectivism pedagogy which believes that “there is only one *true* and *correct* reality” (Vrasidas, 2000, p.3), the constructivism theory asserts the idea of which “knowledge does not exist independent of the learner, knowledge is constructed” [from the environment] (p.7). Hence, despite the theory is further split into two diverted schools — the radical constructivism led by Jean Piaget, and the social constructivism established by Lev Vygotskian (Steffe and Gale, 2009) — the constructivism education approach can be understood as an experience-based learning model. (Cobb, 1994; Jonassen, 1991; Phillip, 1995) The philosophy had been widely studied and implemented in the field of science and mathematics educations, (Hodson and Hodson, 1998; Matthews, 1994; Thompson, 2014; Confrey and Kazak, 2006; Steffe and Kieren, 1994) and it is still considered to be the most adequate framework to develop education models for the field. (Han, Capraro and Capraro, 2014; Freeman et al., 2013) With reference to David Perkin (1999), the constructivist education approaches are supported with both

philosophical and psychological arguments. On the philosophical point of view, constructivists “do not believe that individuals come into the world with their ‘cognitive banks’ already pre-stocked with empirical knowledge, or with pre-embedded epistemological criteria or methodological rules. Nor so we believe that most of our knowledge is acquired, ready-formed, by some sort of direct perception or absorption”. (Phillips, 1995, p.5) Hence, under the mindset of constructivism, knowledge is *created* and learnt from one’s prior experience and/or knowledge. Thus, the knowledge is not restrained as the one and only fact, but instead, knowledge is divergent. Everyone would develop their own conceptions, based on what they have already learnt, their learning style, personalities, and/or social interactions. (Matthews, 1994; Henze and Nejd, 1998, p.2) On the other hand, the above idea echoes with its claim from the psychological point of view. According to findings, active engagement in learning results in better learning outcomes including deeper understandings of the subject matter, as well as a comparatively more dynamic use of the knowledge (than step-by-step instructional approaches). (Windschitl and Andre, 1998) Since a constructivist learning environment respects the learning experience of the students, rather than emphasizing on students’ performance, students are encouraged to “return to their intuitive ideas, unless they have incorporated the models taught”. (Linn, 1995, p.105; Bonk and King, 2012) Moreover, it is suggested that such education approach improves the students’ lifelong learning skill of building on current ideas and developing a more sophisticated repertoire of knowledge. (Linn, 1995; Balim, 2009)

Common implementation of constructivist pedagogies would be the learner-centered activity-based models, or some might refer to it as problem-based learning or project-based learning, with considerations of multiple perspectives. (Von Glasersfeld,

2012; Wilson, 1998, pp.135-141; Honebein, Duffy and Fishman, 1993) Effective activity-based models must present authentic problems with achievable resolutions. Most importantly, the proposed problem should be open-ended, and must engage students with prior interdisciplinary knowledges, experiences or skills. (Perkins, 1991; Jonassen, 1999) According to Peter C. Honebein (1996, pp.11-12), a successful constructivist learning environment should be designed based on the following aspects:

- *Provide experience with the knowledge construction process;*
- *Provide experience in and appreciation for multiple perspectives;*
- *Embed learning in realistic and relevant contexts;*
- *Encourage ownership and voice in learning process;*
- *Embed learning in social experience;*
- *Encourage the use of multiple modes of representation; and*
- *Encourage self-awareness of the knowledge construction process.*

However, paradoxically, constructivist approach in CSI education is not necessarily the answer to the inattention on developing students' digital know-how and know-why.

In 1999, scholar Mordechai Ben-Ari had already addressed the concern about the pitfall of developing CSI education focused on the constructivism approach. By including an example of basic usage of the word-processor on computer, Ben-Ari argued that although the carefully designed interface of the software (i.e. sensible icons and symbols) constructs the knowledge of *how* to do a task, yet the process does not convey the knowledge of *how the software respond* to the command. Therefore, as

he added, to overcome such situation, “the teacher must guide the student in the construction of a viable model so that new situations can be interpreted in terms of the model and correct responses formulated.” (Ben-Ari, 1999, p.3) Thus, while educators are advised to not set activity-goals as evaluation methods, it is "the job of the constructivist teacher (or interactive technology) to hold learners in their 'zone of proximal development' by providing just enough help and guidance, but not too much". (Perkins, 1992, p. 163) Similarly, Jonassen has also pointed out the significance of the educators’ role in designing a comprehensive learning environment to support the construction of knowledges. As he argued in his article, the most important task of the teachers is “providing the intellectual tools [and environments] that are necessary for helping learners to construct knowledge.” (1992, p.12) Moreover, the provided tools and environments should also help learners to “interpret the multiple perspectives of the world in creating their own world view”. (1992, p.12) Brent G. Wilson had further elaborated the idea by considering instructions as a metaphor of time and space (1998, p.3-5) Thus, the learning environment is considered to be a physical space where interactions between the learner and tools/devices, or with other learners, take place. Borrowing his words, a constructivist learning environment is “a place where learners may work together and support each other as they use a variety of tools and information resources in their guided pursuit of learning goals and problem-solving activities”. (Wilson, 1998, p.5)

That said, it is impossible to know in advance the students’ characteristics such as motivation, intelligence and background knowledges when designing instructions or preparing educational materials for the learning activity of any ages. (Cziko, 1989)

2. Bodily Engagement

According to Ernest (1995), the ontology is one of the key components in an educational paradigm along with epistemology, methodology and pedagogy.

Although the ontological reality is generally rejected in constructivist paradigms as we have no way of knowing the “absolute reality” (Ben-Ari, 1998; Glasersfeld, 2012), the search for ontological reality in constructivism is significant to the building of knowledge because “the function of cognition is adaptive and serves the organization of the experiential world”. (Glasersfeld, 1989, p.182) While Piaget had never explicitly discussed the notion of realisms in his works (Piaget, 1976), his idea of “schema” (Piaget, 1952) as the basic building blocks of knowledge implies that an object is “an absolute entity of independent ‘reality’, a thing-in-itself which, through perceived only approximately by our senses, must nevertheless have a structural correspondence to the *phenomenon* we experience sensorially”. (Glasersfeld, 1974) The relationship between our cognition and external objects is therefore inseparable and noteworthy, as learning takes place during the frequent shifting between experience and reflection. (Ackermann, 1996, pp.25-37)

In accordance with the prior discussions, since learning environments as well as user interfaces are purposefully designed instructions for providing implication of knowledge and/or convey the devices’ capacity, we shall consider knowledge to be embodied within the ‘reality’ (as in what can be perceived) while new knowledge is subjectively constructed by the learners individually. In such a way, ontological cognition under constructivist learning approaches can be understood as the process of self-reflection on the learners’ relation of their intrinsic beliefs with the perceived external world. As Glasersfeld also addressed in another article, “from an explorer

who is condemned to seek ‘structural properties’ of an inaccessible reality, the experiencing organism now turns into a builder of cognitive structures intended to solve such problems as the organism perceives or conceives”. (1983, p.50) In other words, ontology assures self-awareness of both the learning process, and the reflection on the knowledge constructed. According to *Principles of Instructional design*, “when learning is first entered into, the learner should become aware of the enterprise for which he or she is aiming” (Gagné, Briggs and Wager, 1992, p.180), for which the term ‘enterprise’ is defined as the intellectual activity involve in regards of the purposive learning activity. (Gagné, Briggs and Wager, 1992, pp.179-180)

This idea can be related back to the philosophy of space, knowledge and power in today’s hypermediated world discussed in chapter one. With reference to Lefebvre’s word, which was also mentioned earlier, a successful educational paradigm for deep-learning shall “not aim to produce a (or the) discourse on space, but rather to expose the actual production of space by bringing the various kinds of space and the modalities of their genesis together within a single theory”. (1991, p.16) Henceforth, in order to design an effective pedagogy for the development of digital know-how and know-why, we should pay attention to the philosophy of existence through bodily engagements with the physical world.

The above ideas of how the human mind emerges from physical interaction with the environment is also supported by various theories such as the Engagement Cognition Theory (Wilson, 2002) and the Embodied Metaphor Theory (Johnson, 2013). Recent researches had also pointed out that Full-body Interactions supports the learning of abstract concepts (Malinverni, Ackermann and Pares, 2016; Bakker, Antle and Van Den Hoven, 2012; Revelle, 2013) While technology-enhanced learning activities are

becoming more and more popular since the last decade in both developed and developing countries (Chan et al., 2006; Gulati, 2008) , the term ‘Embodied Interaction’ had emerged from the growing field of research to specifically define the “interaction with computer systems that occupy our world, a world of physical and social reality, and that exploit this fact in how they interact with us” (Dourish, 2004, p.3). Hence, such ideas have been extensively integrated in HCI designs over the last two decades (Antle, 2013; Hashagen, Büching and Schelhowe, 2009). On the other hand, Full-body Interaction Learning Environments (FUBILEs) are found often to be implemented in the development for STEM education models in the last ten years (Malinverni & Pares, 2015; Malinverni, Ackermann and Pares, 2016). The success of integrating FUBILEs in the education of STEM subjects had drawn researchers’ attention to the cognitive significance of embodied interactions. (Núñez, Edwards and Matos, 1999; Mazalek and Hoven, 2009; Ghajargar and Wiberg, 2018)

With reference to studies in cognitions in computer sciences (Marshall, Price and Rogers, 2003), tangible interactive systems can be classified into two classes (p.102): first, the Expressive Tangible Systems which “embodies aspects of the users’ actions with the system”; and second, the Exploratory Tangible System that does not embody the activity of the users. In short, an expressive tangible system reflects the users’ own action and/or knowledge as an external representation, and it is aligned with the concept of ‘ready-to-hand’; contrarily, an exploratory tangible system is associated with the philosophy of ‘present-at-hand’, for which users are encouraged to pay attention to the way the system works, instead of reflecting on the counterpart of their interaction with the system. Although the mentioned two ways of seeing a system is oriented from the users’ perspective, Marshall argued that the scope of active engagement can be conveyed by designing the nature of the activity. (p.102) As a

result, conceptualizing tangibles allow educators to deliver procedural concepts effectively.

Besides, configuring the actions of bodily engagement in embodied interactions help us discover the potential of HCI, particularly in favor of digital know-how and know-why. Freitas emphasized the significance of analyzing political implications of HCI in the educational environments, as she stated:

“by examining visual perception as something open to philosophical reflection, we can begin to track the way reconfigurations of the sensible—where the sensible refers to what makes sense and what can be sensed—are forged into new political relations within educational contexts” (2016, pp.199-200).

The above argument can be further elaborated by comparing it to the study of linguistic and/or semiotic cognition. According to Siri E. Mehus,

“the significance of an action is not a direct product of the motives and goals that the agent invests in them, but rather issues from its embeddedness in a context, for example the present constellation of co-participant actions and orientations and props for shared and individual activities, so that the meaning and upshot of an ongoing action can be modified by others who may reconfigure that constellation without impacting the physical action itself. Action is distributed.” (Streeck, Goodwin and LeBaron, 2013, p.16)

In this fashion, drawing attention to the bodily engagements in HCI would reveal the physical attributes of the digital device. The political relations of the user and the

environment (including the digital device) shall then become explicit, and therefore stimulates users' philosophical reflections on the connectivity and inter-relations of the user and the environment. Besides, while digital devices are intrinsically functioning as abstract machines with specifically compiled functionalities (as discussed in Chapter 1), such process of active reflection affirms the procedural operation of each functions, for which every feedback from the HCI engagement provides and builds up ones' "structural correspondence to the phenomenon we experience sensorially" (Glaserfeld, 1974, p.99). Thus, it supports the user to develop a structured way of seeing the computational system, and therefore a disciplined thinking of the process behind.

5. Computing and Aesthetics

1. Aesthetic Understandings for Science Educations

The aesthetic understanding of the subject matter has long been associated with the motivation of learning science. (Chandrasekhar, 2013; Root-Bernstein, 1996; Girod 2007) Amongst the discussions on the positive impact of aesthetic understanding on scientific practices, Subrahmanyam Chandrasekhar, the Nobel Prize winning physicist, had commented that "beauty is a guide, a value that scientists use in their work." (Flannery, 1991, p.577) Interestingly, research had also found out that nearly 400 scientists in the 19th and 20th century, including notables such as Thomas Huxley, Lord Rayleigh, Einstein and Heisenberg, were actively participating in non-scientific forms of creativity during their research career. (Girod, 2007, pp.4-5) Whereas the term 'aesthetics' is often associated with the concept of natural beauty, sentiments and passions (Girod, Rau and Schepige, 2003; Good, Keenan and Mishra, 2016), Paul Hunsinger established a different point of view on the philosophy of aesthetics. As he

wrote in the article *Science without Aesthetic*:

“Science and aesthetics will not be dealt with in a polemic fashion since it is assumed that both approaches exist and there is a common denominator - the nature of human beings being human that should hold the two approaches together.” (1973, p.3)

In his perspective, aesthetic is not only the expression of emotions and psychological attitudes, but also concrete representations of information and the communication process.

Although the ideas of the constructivist education model are not explicitly highlighted in the paper, Mark Girod and David Wong’s research (2002), had provided an intriguing approach in designing an effective learning environment for digital know-how and know-why.

With reference to the corresponding research article, the goal of learning science with the current educations are discourse-base conceptual understandings, along with the provision of ‘true’ scientific methodologies about how to question, formulate and argue regarding the subject matter. Hence, they argued that such practices fail to develop students’ critical mindset beyond the internalization of the knowledge ‘ready-to-hand’. For that reason, they proposed the importance of evolving psychological engagement of the students on forming long-term critical perceptions throughout the learning process. Apart from taking into account the concepts on pedagogic theories from influential scholars such as Mikhail Bakhtin, Jay Lemke and Karen Gallas, Girod and Wong had also drawn connection with John Dewey’s view of

learning—learning emerges from “*an experience*” of interaction between the person and the world. (Dewey 1958, 2005)

In Dewey’s perspective (2005), ordinary experiences occur continuously in the very process of living, yet those experiences are often distracted by other ordinary experiences that are taking place simultaneously. Hence, such experiences are inchoate and do not feature an end to itself, but rather a start of another ordinary experience. Since this kind of experiences are not closed, it fails to carry one’s sense of fulfillment, and therefore it cannot be integrated and characterized from other experiences. In contrast, when the experience is round and complete, it will have an ‘individualizing quality and self-sufficiency’ which allows the person to fully, and distinctively internalize the experiences. Those extra-ordinary experiences are referred to as “*an experience*”. Borrowing Dewey’s words, *an experience* is “active and alert commerce with the world; at its height it signifies a complete interpenetration of self and the world of objects and events”. (p.18) It is believed that *an experience* is easily remembered, and it serves as the access-points and/or references to change the way one perceives the world by foreshadowing future happenings, awakening anticipation and initiating actions. (Pugh and Girod, 2006, pp.11-12) Thus, based on this philosophy, Pugh (2002) had introduced the term ‘transformative experience’, and used it as an assessment prospect for analyzing the level of engagement of science students. According to his proposal, a transformative experience is formed with:

1. active use of the concept,
2. an expansion of perception, and
3. an expansion of value.

2. Art and Computational Thinking

Art education and art making can be considered as transformative experiences.

Recently, the employment of digital technology in art had been advocated by the increasing incentives provided by art education scholarships or research funds recently. (Buffington, 2008; Hsu and Lai, 2013; Keifer-Boyd, 1996; Taylor and Carpenter, 2002; Carpenter and Taylor, 2003; Pepler, 2010) Inspired by such phenomenon, art educators Aaron D. Knochel and Ryan M. Patton argued that “art education can play a role in developing the critical thinking skills of 21st century students by augmenting the K-12 art curriculum to include computational thinking as a practice of critical digital making—a creative process using programmable objects to engage with sociocultural contexts to make art”. (2015, p.22) Here, the idea of critical thinking and computational thinking is compared with each other, and it is believed that they share the same, or at least highly similar, cognitive practice. Hence, to make explicit the connection between the two ways of thinking, Knochel and Patton proposed the use of art education (together with art making) as *the* environment to support the development of the mentioned lifelong learning skills. (p.23-25)

As they continued to elaborate on the concept, the importance of materiality in computer sciences to the pedagogy of computational knowledge is highlighted by juxtaposing Seymour Papert’s theory of constructionism¹ (Papert and Harel, 1991) with his creation of the visual programming language, Logo (1980). With reference to

¹ Papert is a student of Jean Piaget, and his theory of constructionism is developed based on his mentor, Piaget’s philosophy of constructivism.

scholars of constructionism, the emphasis on artifacts should be paid more attention to, since “meaning-construction happens particularly well when the learners are engaged in building external and sharable artifacts”. (Kafai and Resnick, 2012, p.17) Again, this concept of cognition development overlaps with the philosophies we have discussed earlier: the physical objects are embodied with a set of ideas and concepts of how we perceive the world, and thus these artifacts advocate how we think about, and react with things. Moreover, the idea also echoes with the claim of seeing pedagogic tools as the “building-blocks of knowledge”. In an art making environment, students are motivated to make use of the resources available to produce something creative. In other words, students must be actively *thinking* about the subject matters, and put the abstract concepts into action (As in present-at-hand).

Apart from shedding light on the substantial value of the physical attributes of digital devices, the Knochel and Patton have also provided a fresh perspective on the understanding of digital devices: the code is seen as a piece of critical text with “a process of design informed through social, political, and cultural frameworks” (2015, p.28), rather than lines of technical practices or algorithmic commands. From this perspective, individuals are encouraged to not only reflect on their interrelation with the technology, but also become aware of the role and impact of the digital media with the external world.

Along this logic, building of computational thinking through an art education environment does not just contribute to the development of individuals’ ability of computational thinking, it also stimulates ones’ critical thinking skills. Hence, more active exercise of critical thinking helps individuals to question, and even deconstruct the contained environment. (Medina, 2012, pp.36-38) Hence, whilst the students are

encouraged to reflect critically on the subject matter, their identity, prior knowledge, feelings and opinions are valued as the key conductor in the learning process. (Medina, 2012, p.40)

The power relations under the human-computer interactions are then revealed to the individual. As a result, the experience also acts as a process of empowerment, as one becomes more aware of the capacity of their bodily actions. Thence, through art education, the students will gain new perspectives on seeing the world, and therefore establishes ones' new values.

6. New Media Arts as an Alternative Pedagogy

1. Nature of New Media Art

1. History and Definition

With reference to Mark Tribe (2006), a contemporary artist who is also the founder of Rhizome, New Media art is a unique, yet broad category of art which emerged at the end of the 20th century, when video art and interactive installations begun to be more popular in museums and exhibitions than conventional mediums such as sculpture and paintings. (Tribe, Jana and Grosenick, 2006, p.9) This young field of practice is also often referred to as “digital art”, “computer art”, “multimedia art”, or “interactive art”, and some other more. These terms have been used interchangeably to describe projects that “make use of emerging media technologies and are concerned with the cultural, political and aesthetic possibilities of these tools”. (p.6)

According to artist and curator Simon Penny, interactive art carries two aesthetic tasks: first is “to discover the nuances and modalities of the interactive dynamic, and to find

out how to apply these to esthetic goals”; and second is “the integration of the esthetically manipulated interactive dynamic with the other components of the work, be they physical objects, images or sound, into an integrated esthetic whole.” (Penny, 1996, 4th paragraph)

On this account, the aesthetic of new media art is first found in the essence of interactions within or between the abstract system, the physical devices and the audiences. Hence, the notion of so-called aesthetic appearance is merely a supplementary aspect of captivation of new media art.

2. Aesthetic in the Procedural Processes

As interactive art is mediated by various digital technologies, new media art instinctively embodies the systematic structure of digital medias. Hence, to uncover the interaction dynamic among and/or within the systems (either physical or conceptual), an artist must be conscious of the procedural operations of the media, and stage it correspondingly as the primary aesthetic of the art work. This association of algorithmic functions with aesthetic expression is referred to as “computational aesthetic”.

In research conducted by Gary R. Greenfield (2005), “computational aesthetic” is found to be originated from the field of mathematics and computer science, and similar concepts were referred to in various way, such as “information aesthetics”, “generative aesthetics”, “abstract aesthetics”, “algorithmic aesthetics” and “emergent aesthetics”. (Greenfield, 2005, pp.9-12) From this brief outline of the history of the term, we can easily identify the interest on the ‘work of art’ lays upon on the

procedural function of computers.

Hence, while some argues that computational aesthetic is a research framework for creating “computational methods that can make applicable aesthetic decisions in a similar fashion as human can” (Neumann et al., 2005, p.16), the idea is also associated with the unique perception to appreciate the process of the forming of interactions.

According to computer artist Frieder Nake, the term “computational aesthetic” is emerged to focus on obtaining “a scalar or vector measurement of the aesthetics of a *work of art.*” (Greenfield, 2005, p.2) Besides, it is also pointed out that “the aesthetics of digital media are instead manifest in process; a process in which a computer, its processes, and a user all work together.” (Barker, 2012, p.97)

3. Embodied Interactions

The enchantment of new media art is not limited to its computational aesthetic nor its conceptual confrontation. It is also found in its support of interactivity.

On commenting on one of his most successful interactive installation *enter*, interdisciplinary artist Nathaniel Stern explained his view on interactive art:

“it is a *situation* that accents embodiment and signification as on the same plane of existence. It *frames* how we *move-think-feel* with and as an active body, with and as an articulation of meaning. [.....] This body is a dynamic form, full of potential. It is not ‘a body’, as thing, but *embodiment* as incipient activity.” (2013,

p.2)

Thus, on this account, individuals are encouraged to critically analyze and *think* about the integrated procedural function of the interactive artwork through experiencing the abstract concepts with bodily engagements.

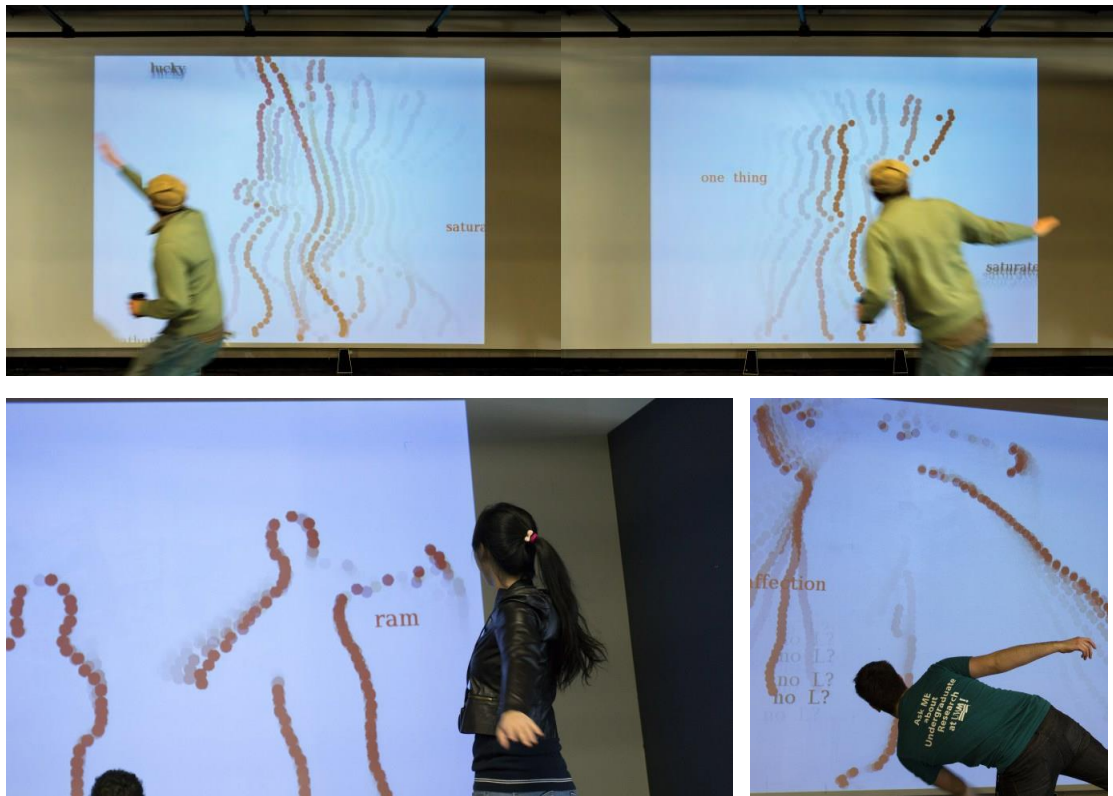


Figure 1. Nathaniel Stern, *enter*, 2000-2013 Courtesy of the artist

Moreover, Stern continued to discuss the role of embodiment in relation to the assertion of power over the bodily practices of oneself. Under the discussion of the ability of meaning-making from bodies in the encounter of interactive art experiences, he noted:

“technology and the artwork are not acting as catalysts or glue that combine two things (which are not things); they act as a rig, a quotation, a suspension and

intervention into, matter and matters that are always already in relation are necessary – are in fact the very pre-condition – for being(-with).” (2013, p.124)

With reference to the interrelation of ontology and learning experiences discussed in Chapter 3, new media artworks can be perceived as an environment which reframes the consciousness of *self* and *being* of an individual, as well as the existence and function of the digital device, rather than only a medium to convey a certain value of aesthetics. Hence, in this context, the computational aesthetic would be perceived as matter ‘present-at-hand’.

4. Active Cognitive Engagement derived from Physical Interactions

In respect to the ideas quoted above, new media art has a characteristic of revealing the *situation* of the technology-mediated encounter. As a result, the construction of a space, and/or the device or the machine (that are incorporated with the art work) is explicitly presented to the audience. Thereby, the environment by itself suggests the connectivity and inter-relations of its contained object.



Figure 2. Nam June Paik, *TV Buddha*, 1976 © Nam June Paik Estate



Figure 3. Jeffrey Shaw, *The Legible City*, 1989 © Jeffrey Shaw

Going back to Foucault’s philosophy on power and knowledge, just as power is both generated from within and exerted from the environment, whilst the environment is often a result of one’s utilization of technology and take of actions, knowledge is both conveyed from external objects and created from one’s exertion of their power. As he wrote in *Discipline and Punish*:

“it is not only the activity of the subject of knowledge that produces a corpus of knowledge, useful or resistant to power, but power-knowledge, the process and struggles that traverse it and of which is made up, that determines the forms and possible domains of knowledge.” (1979, pp.27-8)

Following this logic, the notion of power, knowledge and space aligns with the beliefs of the Constructivist pedagogic approach. Yet, subsequently, Foucault had associated this concept with the idea of ‘docile bodies’ which indeed disciplines and subjugates

learners, and therefore hinders them from achieving critical engagements. (Goodson and Dowbiggin, 1990) Although Foucault's idea on the integrative relationship between power, knowledge and space helped us illustrate the role and competency of digital devices in HCI, his theories does not propose solutions for the development of pedagogy for digital know-how and know-why: Foucault's view on education only encourages students to understand and internalize the presented knowledge through interacting with (i.e. exerting power over) it, rather than facilitating the students' to think about the knowledge and learn from *their* own understanding and interpretation. Hence, to take this concept one step further, we shall also consider Deleuze's concept of "deterritorialization" through bodily practices as the process of 'becoming'—the realization of *self* and its potential of *creating*. (Bankston, 2017; Clegg, Kornberger and Rhodes, 2005; Massumi, 2013; Zepke, 2014)

Correspondingly, as individuals come to realize the relational dynamic between their physical body and the world, they are encouraged to also reflect on the connection between the cognitive *self* and the cognition of *existence*. (Hansen, 2004) Hence, with reference to the learning theories discussed in part three of Chapter 3, we may conclude that knowledge of the technological capacity (i.e. *what* the machine does) as well as the conceptual process (i.e. *how* the system works) can be easily absorbed by the audience, through the naturally situated process of active and frequently-shifting engagement of physical experience and abstract reflection throughout the encounter with a new media artwork.

5. Media Art as the Art Making Experience

While digital media is extensively permeating our everyday life, interactions with

various technologies had become ‘natural’ gestures that we practice intuitively. Just as it was discussed in Chapter 2, GUI and NUI designs would be the contemporary examples of achieving ‘intuitive’ Human-Computer Interactions.

As new media art fundamentally embodies the use of media technologies, it is unavoidable that, although they often present unusual (or even absurd) and challenging concepts, the physical nature of new media art still comprises the everyday encounter with digital media. Interactivity in the encounter with new media arts are supported by the GUI or NUI designs. That said, despite the argument that Graphic-User Interface (GUI) and Natural-User Interface (NUI) both prevent users from realizing the devices’ mediated nature (for instance, computational functions are represented by conceptual symbols or icons), the metaphoric elements (i.e. the symbols and icons, and/or artistic expressions) of the new media art serve as an external reference which indeed helps one to develop a more profound understanding on the subject matter. (Rogers, 1898, p.468-469)



Figure 4. Rafael Lozano-Hemmer, *Bifurcation, Shadow Object 2*, 2012. Courtesy of the artist

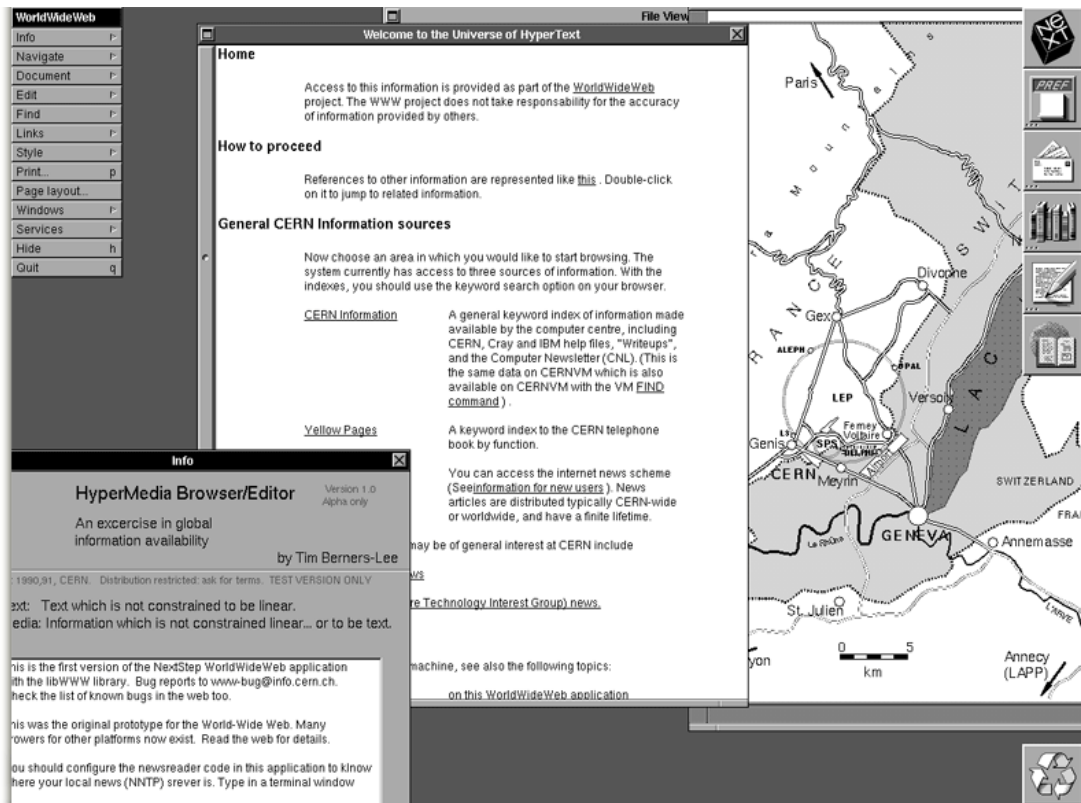


Figure 5. Tim Berners-Lee, *WorldWideWeb*, 1990 Screenshot of a NeXT Computer

Courtesy of the artist

On the other hand, with reference to Andrew Dewdney and Peter Ride on the nature of new media art, it is commented that despite every artwork being a product of the artist him/herself, the interactivity in new media arts allows an audience to become part of the creation of the work. This is because:

“digital media represents a convergence of previously distinct communication forms in which skills and practices overlap and boundaries between previously distinct operations of production blur. This convergence leads to greater team working and collaborative approaches, which require a creative synergy between people working together.” (2014, p.7)

As stated in Chapter 3 under the sub-section *Bodily Engagement*, active interactions and full-body engagements are two of the key aspects of deep-learning. Hence, according to Kylie A. Pepler, involvement in art making is important from both the perspectives of Dewey and constructionist (and/or constructivist) theorists, because it “engages youth in the process of building, creating, and constructing artifacts—whether digital or physical.” (2012, p.2123) Thus she had also explicitly addressed the role of interactivity in new media for forming deep-learning experiences. As she wrote:

“Interactivity in new media can also explore further ideas such as the subject’s relationship to technology, allow the subject to influence the production of the object, reverse the subject–object relationship, and blur the boundaries between the relationship or at least make us aware of it. The concept of interactivity becomes a key feature as we think about learning in this new landscape— one that ties nicely to some of Dewey’s ideas on activity and experience. “(2010, p.2125)

2. Experiencing Media Art in the Museum Context

1. Open-ended Space

Educator Andrea Kenkmann (2010) compared the power-space relationships of a classroom and that of a museum space with her experiences of teaching adults in the two varying spatial contexts. She noticed, the power dynamic in a classroom is an implicit hierarchical power structure established once the teacher enters the classroom. Yet, in contrast, when she had her classes in a museum space, learners navigated through the space freely without seeking approval in advance from the tutor. Hence, she elaborated that such differences are likely to be a result from the different spatial

structure between the two: in classrooms, there is a spatial gap between the teacher and the group of students; whilst in a museum, the space is neutral and homogenous — there are no boundaries in between visitors and exhibits.

Hence, unlike classroom contexts, museum space does not establish the learners as ‘docile bodies’. Indeed, museums allows a free flow of power dynamic between the learners and the educator, which in this case would be the exhibits and other supplementary informative materials present in the exhibition space. Similarly, in the museum space, knowledge is perceived as a divergent creation that emerges through social interactions, rather than a one and only ‘truth’ informed by the educator.

Moreover, according to Eilean Hooper-Greenhill (2006, p.5), exhibitions are designed for ‘the general public’. Thus, museums are:

“becoming more aware of the importance of the social context of museum visits, and of the fact that museum visitors do not become new-born beings as they enter the museum. People come to museums carrying with them the rest of their lives, their own reasons for visiting and their specific prior experience.”

Although it is noted that museums would also design exhibitions for ‘target groups’, the different expectations, reasons to approach and needs during their visits are still treated as the fundamental considerations when developing museum campaigns.

(Hooper-Greenhill, 2006, p.6)

Museum spaces are therefore open-ended space which values the individuality of the learners (visitors). Consequently, without constrained by the “absolute truth of

knowledge”, individuals are encouraged to establish intuitive ideas based on the repertoire of their prior knowledge, skills and experiences. As a result, the encounter with new media arts allows individuals to undergo cognitive interactions and deep-learning activities through real-life experiences.



Figure 6. Daniel Rozin, *Peg Mirror*, 2007 Courtesy of artist

2. The Museum Experience as *An Experience*

In the book *Reshaping Museum Space* (Macleod, 2006), it is pointed out that museums are built with the objective to provide visitors with a unique experience, formed by creating direct relationships between the viewer, the space, the content and the context. Besides, museums are also designed to be flexible and open to changes in response to contemporary issues and agendas. Moreover, it is also identified that museum spaces are commonly curated for exhibitions that enable visitors to have a certain level of engagement with the subject matter, and at the same time providing space for imagination, contemplation and reflections.

While new media art is proposed as the “building blocks” of digital know-how and know-why, appropriate curatorial practices must also be incorporated to achieve pedagogical objectives for the development of digital know-how and know-why. Despite interactions with media art embodying core learning experiences such as creating self-awareness in relation to the subject matters, valuation of individuals’ identity and prior knowledge and skills, the interactive artworks are merely a tool of constructing knowledges. Hence, if it is to be associated with the development of digital know-how and know-why, implicit guidance is needed to help draw focus on the subject-matter, and facilitate the development of self-constructed understandings. (Perkins, 1992)

According to the theory of constructivist pedagogic approaches discussed in Chapter 3, implicit instructions can be seen as a metaphor of time and space. (Wilson, 1996, pp. 3-5) As we consider New Media art as the tool of knowledge “building blocks”, the exhibition space in the museum which hosts the interactive artworks shall be seen as the instructive time and space for the learning activities to take place.

As curatorial practices take place within the confronted museum space, the works of art in the exhibit are considered to be interrelated, and it is sometimes even politicized, to altogether convey meanings. (Greenberg, Ferguson & Nairne, 2007) As a result, exhibitions in museums becomes “contemporary forms of rhetoric, complex expressions of persuasion, whose strategies aim to produce a prescribed set of values and social relations for their audiences.” (O’Neil, 2007, p.16) A conceptual, as well as spatial, structure with a beginning and an end is defined in the museum space.

Thereafter, if we compare the above conceptions of a museum with Dewey's philosophy of *an* experience, we could see that museum is an enclosed environment with 'individualizing quality and self-sufficiency'. As curatorial practices transform the space into an organized information space, a need to "understand how individuals choose to pull together, sift through, organize, and present information" is created. (Mihailidis, 2013, p.3) Hence, within the curated exhibit, visitors would go through a whole, comprehensive experience with regards to the subject matter. Thus, the round and complete experience allows an individual to fully, and deeply reflect on and learn from the various materials and interactions encountered.

7. Conclusion: Is Curatorial Practice as an Alternative Pedagogy a Dilemma?

However so, due to the divergent medium in New Media arts, the curatorial practices are yet underdeveloped. (Graham, 2015) At the same time, museums and galleries are often reluctant to participate in collecting and exhibiting new media artworks, for a simple reason that "the work is difficult to collect, curate and display". (Gere, 2008, p.24)

That said, interdisciplinary practice between art and science are becoming more and more common in cultural, educational and academic practices. (Ascott, 1998; Fishwick, 2008; Manovich, 2003) For instance, there are various international media art festivals, such as the Ars Electronica Symposiums and the Transmediale Festival; as well as exhibition spaces, namely the Science Gallery in Dublin, London, Melbourne, Bengaluru, Venice and Detroit. Besides, there are also museums that are dedicated to the pedagogic development of digital know-how and know-why. An example would be the NTT InterCommunication Centre in Tokyo, which had been

actively engaged with collaborative practices between multimedia artists, scientific research laboratories and the community through curated exhibitions and public workshops since 1990. (NTTICC, 2016)



Figure 7. Lobby of NTT ICC, Tokyo ©NTT InterCommunication Center



Figure 8. Collage of photos from the ICC Kids Program, NTTICC, Tokyo

©NTT InterCommunication Center

Considering the above examples, although curatorial practices of new media art are still being discussed in the field of museum studies (Morris, 2001; Muller, 2008), various curatorial theories and approaches have already been practiced in real world. Hence, we may conclude that it will only be a matter of time until pedagogical curatorial practices will be adopted for new media art exhibitions to achieve deep-learning of digital know-how and know-why.

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