教育資料與圖書館學

*Journal of Educational Media & Library Sciences*

http://joemls.tku.edu.tw

Vol. 56 , no. 1 (2019) : 45-68

# 兒童學習運算思維概念與數位策展能力的關聯性研究初探

# Does the Learning of Computational Thinking Concepts Interact with the Practice of Digital Curation in Children? A Preliminary Case Study

張 君 豪 Chun-Hao Chang
Post-doctoral Researcher
E-mail：chunhao.chang@tc.columbia.edu

**Chinese Abstract & Summary see link at the end of this article**

*Journal of Educational Media & Library Sciences* 56 : 1 (2019) : 45-68
DOI:10.6120/JoEMLS.201903_56(1).0033.RS.CE

Research Article

# Does the Learning of Computational Thinking Concepts Interact with the Practice of Digital Curation in Children? A Preliminary Case Study

**Chun-Hao Chang**

***Abstract***

*Digital storytelling with block-based coding tools for children involved the exercise of both computational thinking (CT) and digital curation (DC). Relevant studies, however, were more concerned with the learning and development of CT concepts rather than the practice of DC. In this regard, the current study aimed to investigate the interrelationship between the learning of CT and DC through digital storytelling, particularly from the standpoint of elementary school children. A total of 35 fifth graders were recruited from a public school in New York City to voluntarily participate in a ten-week digital storytelling workshop where they curated an interactive story within the Scratch environment. Self-made scoring rubrics were implemented to evaluate students' digital storytelling projects from two measures: Computation Measure and Curation Measure. The overall analysis revealed no significant correlations between the two measures. Further investigations, however, on the interrelationship between each of the subcategories of the two measures indicated a number of significant correlations between the learning of CT concepts and the practice of DC. Relevant educational implications were intensively discussed to inform the design of teaching and curriculum.*

***Keywords:*** *Computational thinking, Digital curation, Digital storytelling, Scratch, K-12 education*

## Introduction

The cultivation of computational thinking (CT) skills at an early age is a topic that has gained universal awareness and acceptance in recent years. In a broad sense, CT skills can be perceived as general information literacy skills that have the potential to benefit young children's cognitive learning and thinking capabilities (Grover & Pea, 2013; Kafai, 2016; Voogt, Fisser, Good, Mishra, & Yadav, 2015). The study of CT produces practical knowledge of how to analyze and solve everyday problems by reflecting on how computer scientists would approach a problem in a systemic fashion. By acquiring this literacy skill, children

Post-doctoral Researcher, Department of Computer Science and Information Engineering, National Taiwan Normal University, Taipei, Taiwan
E-mail: chunhao.chang@tc.columbia.edu

2018/10/16 received; 2019/01/26 revised; 2019/01/31 accepted

learn not only problem-solving techniques but also fundamental principles of computation. The concepts of CT are abstract in nature, however, and are not easy for children to comprehend. One of the methods commonly adopted to assist children in making sense of abstract CT concepts is interactive, digital storytelling with block-based coding tools (BCTs). A BCT often incorporates a design that encourages children to practice CT concepts within a narrative context, such as an interactive story. A typical BCT, such as Scratch or Blockly, enables children to freely tinker with their ideas by an intuitive drag-and-drop process. In other words, children can delve directly into the learning of rudimentary CT concepts without memorizing complex syntax rules. Children can quickly create functional prototypes of their story ideas by snapping different colors of building blocks together, in a way that is consistent with their Lego building experiences. This process of virtual building block design and construction guides children to discover how each CT concept functions, both individually and together, to support the plot of an interactive story.

Though children were first thought to learn CT concepts by applying computational constructs to the design of digital stories with BCTs, it was later found that they seemed to be immersed in the process of creating story characters, selecting costumes, editing sound clips, or generating animation effects (Adams & Webster, 2012; Kafai, Peppler, & Chapman, 2009). For instance, with Scratch, its abundant multimedia resources, ranging from images, clip art, graphics, and audio clips, encouraged children to constantly use their imaginations to expand the scope of storytelling. Children could use multimedia elements to strengthen the narrative, organization, and interactivity of the story; this was often regarded as a motivating factor rather than a meaningful learning task in a CT classroom. From one standpoint, that of how well children were learning CT skills, this shift of the learning focus from CT concepts to a multimedia presentation could not only distract a student from concentrating on computational constructs but could lead the student to deviate from the original instructional goals. From another standpoint, however, that of library informatics, all of these caveats about learning could be given a new impetus and meaning: They could all be perceived as a form of digital curation (DC) practice, a process that generally involves digital content selection, information filtering, narration structuring, and public sharing (Albion, 2014; Fotopoulou & Couldry, 2015). In fact, when children acted as a multimedia storyteller in a BCT, they did not practice CT skills alone but DC skills as well. They learned how to program their story characters and how to select, filter, and arrange multimedia resources in relation to the plot of a story. Although BCTs were not originally designed for digital curation, they allow children to experience curating a multimedia exhibition of works that address their imaginations.

Following this, the exercise of a child's CT skills and DC skills could be intertwined in digital storytelling activities. This prompts the question of how children would handle these two skills, which are seemingly at variance, at the same time and how digital storytelling with BCTs can propel children to cultivate two sets of skills in one piece of work.

An overview of the literature on the effect of digital storytelling on children's cognitive development has shown that a substantial body of research has focused on the cultivation of CT skills, whereas the development of DC skills is rarely mentioned. Some studies revealed that digital storytelling with a BCT resulted in an effective understanding of abstract CT concepts by elementary school children (Burke & Kafai, 2010; Wilson, Hainey & Connolly, 2013). Others highlighted the effect of digital storytelling on children's critical thinking and creativity (Niemi, Harju, Vivitsou, Viitanen, Multisilta, & Kuokkanen, 2014; Psomos, & Kordaki, 2012) but included little about its effect on their DC skills. Although CT skills and DC skills seemed to vary in nature and scope, they were both essential skill sets for children to attain in order to formulate their mental representations of a problem. They both served as a framework for outlining and guiding a child's cognitive thinking activities. One might ask several questions about the two skill sets, such as what is the relationship between them? Could a student's CT skills become an indicator of his or her DC skills? Could a student's DC skills complement or conflict with his or her CT skills? Are there any possibilities to design and implement an interdisciplinary curriculum to cover both DC and CT skills through one learning task? All these questions await further clarification and elaboration to increase our knowledge about and enhance the discussion of this subject.

# Literature Review

## Digital Curation and Digital Storytelling

DC is an interdisciplinary concept incorporating aspects of content curation and digital resource presentation used primarily by the scientific and digital library communities respectively (Beagrie, 2006; Molloy, 2014). By definition, DC is basically a process through which a person collects, filters, organizes and presents a particular topic out of a larger collection with digital media, similar to how a museum curator or archaeologist brings together an exhibition from a particular frame of reference (Albion, 2014; Boon, 2011; Dale, 2014; Fotopoulou & Couldry, 2015; O'Neill, 2006). However, the application of DC is not limited to museums or art galleries. In other settings such as libraries, one of a librarian's core duties is to curate reference materials or online resources to support various needs of routine learning and teaching activities. Librarian must be capable of collecting targeted information effectively through researching, filtering, categorizing and assessing its the relevance to the reader. In this regard, DC can be described one's mental representation of information, through which one imparts his or her own interpretation that is carefully designed and arranged to facilitate learning from the audience's perspective. In other words, DC can be described as a meaningful abstraction of information with aims to present the essence of a selected theme. To further illustrate the process of meaningful information abstraction, Deschaine and Sharma (2015) argued that DC should be implemented as a staged, sequential process that covers activities such as: (a) content collection, (b) content organization, (c) content critique, (d) content conceptualization and (e) content circulation. Though these activities are presented as a list, they do not necessarily occur in linear order, meaning a curator may switch from process to process until the final objectives are achieved. Hence, the curated content is narrative and provides a story as well as reflection of the curator's view of the world. This staged framework not only highlights the core components of DC but also sheds light on the similarity between DC and digital storytelling.

Storytelling is a natural way for human beings to recount experiences and create reasonable order out of experiences (Erickson, 1996; Gottschall, 2013; Moen, 2006). In essence, storytelling is a form of curation. The act of storytelling often begins with selecting a topic, structuring ideas, creating characters and organizing the story's plot, a process that is similar to curate an art exhibition. This procedure helps storytellers externalize their thoughts and imaginations through multimodal representations (Connelly & Clandinin, 1990; Isbell, Sobol, Lindauer, & Lowrance, 2004; Porter, 2004), and henceforth can serve as a pedagogical tool to foster children's thinking and self-reflections (Sadik, 2008). With the advancement of digital technologies, the notion of digital storytelling has emerged to enable new forms of creation. Digital storytelling can be described as ordinary storytelling with the enhancement of digital media or technology tools (Howell & Howell, 2003). Digital stories derive their power by weaving images, music, narrative and voice together, thereby giving deep dimension to characters, situations, experiences, and insights (Rule, 2010). In practice, the process of digital storytelling can be considered as an instance of DC from two standpoints. First, both digital storytelling and DC involve the creation of narratives through active, meaningful selection, organization and filtering of information based on personal perspectives (Mihailidis & Cohen, 2013). For both digital storytelling and DC, the final product is personal and unique, is representative of one's own creativity, and is carried out through a structured thinking framework. The ultimate goal is set to filter out irrelevant information in order to construct a well-organized, self-contained curation project. Second, both digital storytelling and DC pivot heavily upon one's mental representations of the content to be demonstrated (MacDonald, 1998).

In terms of assessment, three approaches were found in the literature when examining a person's curation skills. Some conducted surveys questions (Creamer, Morales, Crespo, Kafel, & Martin, 2012); some designed self-made scoring rubrics (Cowick, 2018), still others implemented in-depth interviews (Molloy, 2014) to examine differences in students' DC skills. However, since one's curation work tends to be highly context-dependent, it becomes difficult to develop a standardized, unified assessment method that fits all purposes. In this study, we intend to implement scoring rubrics to examine students' in digital storytelling within the Scratch environment. Considering the multimedia features of a Scratch project, we particularly incorporated content interactivity and multimedia design as two new dimensions when assessing students' DC skills. These two dimensions reflect the nature of using digital technologies to curate a story. Therefore, aside from the dimensions of DC summarized in previous literature, following is the framework of DC skills proposed in this study:

- Content selection: the active selection and filtering of the content in order to generate the main theme of the digital story.
- Content organization: the organization and sequencing of the curation content with references to the plot of the digital story.
- Content originality: the originality as well as authenticity demonstrated in the curation content.
- Content interactivity: the level of interactivity and the design of interactive mechanism conveyed through the curation content.
- Multimedia design: the design and integration of various multimedia elements in the curation content.

## Computational Thinking and Digital Storytelling

The cultivation of CT skills has listed as one of the core competencies for children to acquire, just like skills in mathematics and sciences. CT refers to a general analytical approach to problem-solving, designing systems and even understanding human behaviors (Barr & Stephenson, 2011, Guzdial, 2008; Wing, 2006; Wing, 2008). It is not a skillset merely for computer scientists to master; instead, it should be treated as a generic literacy skill shared by a wide spectrum of academic disciplines (Wing, 2008; Wolz, Stone, Pearson, Pulimood, & Switzer, 2011). CT related learning activities can be grouped into two categories — comprehension and generation. Comprehension focuses on one's capabilities to outline program structure for testing and tinkering; generation focuses on the ability to implement proper solutions with references to the comprehension

(Robins, Rountree, & Rountree, 2003). It was found a well-trained learner with CT skills should possess two type of knowledge: (a) Knowledge about the computational design plans, which are generic computer program fragments that represent stereotypic action sequences in programming. (b) Knowledge about carrying out the design plan with tools, which capture the conventions in computer programming and guide the composition of the design plans (Soloway, 1984).

Researchers were concerned about whether children could benefit from learning CT knowledge at a broader scope and, in the meantime, cultivate an integrative view on CT concepts (Kurland, Clement, Mawby, & Pea, 1986; Xinogalos, 2012). One of the essential tasks in CT is to generate symbolic abstractions of problems with respect to computational rules to represent a person's mental understanding and thinking. This process involves researching, filtering, categorizing and sense-making, which appears to be similar to the process of telling a story. Thus, engaging children in designing digital stories or animations has become a popular approach to practice basic, abstract CT concepts. In relevant studies, fundamental CT concepts includes the following categories (Brennan & Resnick, 2012):

- Sequence: to design a series of individual steps or sequential instructions for a particular activity.
- Event: to identify the causal relationship among things in a particular activity.
- Conditionals: to make decisions based on certain conditions or assign different outcomes with respect to different conditions
- Loops: to repeat a sequence of instructions until a certain condition is met.
- Variables: to store, retrieve and filter data as a virtual container for a particular activity.

Since the above CT concepts are abstract to children, interactive stories or animations are often used as a vehicle to demonstrate how each CT concept is associated with the plot of a story. For instance, the conditionals concept controls the flow of a digital story. Therefore, digital storytelling can be described as an instance of CT through which a person externalizes his or her understanding of abstract CT concepts. The narrative of a story and interactions among characters can be broke down into single or a combination of CT concepts. Through digital storytelling, students can more effectively recognize how to enhance the interactivity of a story through applying CT concepts. Papert (1980) argued that the development of CT concepts is analogous to building up a microworld to represent a person's conceptual understanding of computational knowledge. In other words, when a storyteller engages in the process of building up a digital story with a tool such as Scratch, he or she is placed in a self-constructed microworld to testify how CT concepts should be applied to story narratives.

In sum, digital storytelling with BCTs is a learning task that encompasses the exercise of both CT and DC. In other words, when students engage in digital storytelling activities, they seek to achieve the same goals by applying two seemly different abilities at the same time. The learning of DC skills put emphasis on the selection, organization, originality, interactivity and multimedia design of digital content; the learning of CT concepts revolves around the planning, designing and implementation of different computational constructs such as sequence, event, conditionals, loops and variables. In contemplation of the relationship between CT and DC skills, we developed the following three research questions to guide the study.

1. How do students curate a digital story in terms of the five dimensions of DC (i.e., content selection, content organization, content originality, content interactivity and multimedia design)?
2. How do students design a digital story in terms of the five concepts of CT (i.e., event, sequence, conditionals, loops and variables)?
3. In digital storytelling activities, what is the interrelationship between the learning of CT concepts and the practice of DC?

# Method

## Participants

The study consisted of 35 students (16 males and 19 females) in the fifth grade between the ages of 10 and 11. All students were recruited from a public elementary school in the Washington Heights neighborhood of New York City. Participation in the study was completely voluntary and no incentives were offered for participation. Prior parental consent was obtained along with signed informed consent forms. Each student was asked to attend a 55 minutes storytelling workshop every week for ten consecutive sessions, during which they learned to create an interactive story within the Scratch application. None of the students had any prior computer programming experience or knowledge of the Scratch application.

## Research Design and Procedure

The weekly Scratch design sessions were held as a storytelling workshop where students took the role as a storyteller to curate an interactive story based on their preferences. The same instructor was assigned for the workshop with assistances from two on-site teachers throughout the study. Each student was equipped with a labeled personal laptop as the design tool. There was no Internet connection in the classroom, meaning students were only allowed to import multimedia resources from the Scratch application to curate their interactive stories. The storytelling workshop generally consisted of two parts: the first 30 minutes was reserved for guided instructions, followed by a 25 minutes hands-on Scratch design session. On day one, prior to the beginning of guided instruction, students were taught what constituted a story and what details appealed to the audience through in-class discussions.

The ten-week digital storytelling curriculum consisted of five different types of CT concepts based on Brennan and Resnick's (2012) categorization, including (a) event, (b) sequence, (c) conditionals, (d) variables and (e) loops. These concepts were taught one by one from simple computational construct such as event and sequence to sophisticated computational construct such as conditionals and variables. An overview of the curriculum design framework was illustrated in Figure 1.

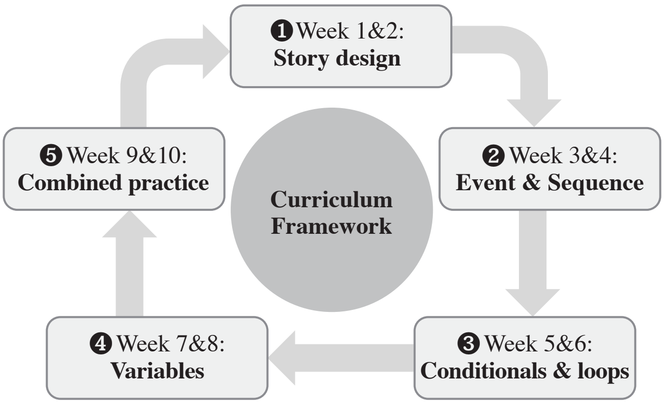


**Figure 1 An Overview of the Curriculum Design Framework**

Through guided instructions with worked examples, students learned to apply CT concepts one by one to build up their interactive stories through tinkering with Scratch building blocks. Two examples of students' curation project with Scratch were presented in Figure 2.

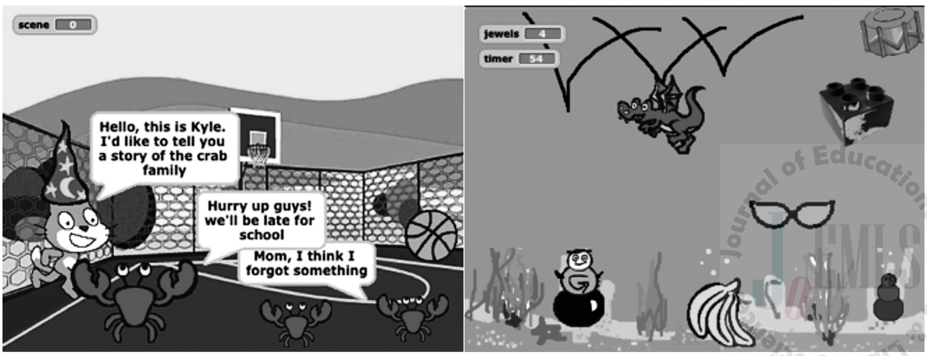


**Figure 2 Examples of Student's Digital Curation Project with Scratch**

The Scratch application was chosen as the digital storytelling tool for two reasons. From the perspective of CT, Scratch is a block-based, visual programming environment that enables students to quickly grasp CT concepts in an intuitive approach. From the perspective of DC, Scratch offers abundant, ready-made multimedia resources for students to curate a story. These resources include photo images, illustrations, clip art, sound tracks and animation effects. Scratch has been experimented as an effective digital storytelling tool for young children in previous studies (Bratitsis & Ziannas, 2015; Lye & Koh, 2018). Students can easily import these ready-made multimedia elements to their stories. In addition, the share button offered by Scratch allows students to quickly publish their projects with a wider audience in a timely manner. All these functionalities make Scratch an ideal tool for the exercise of both CT and DC skills at the same time.

### Measures

There were two measures administered at the end of the workshop to investigate participants' DC and CT skills. The Curation Measure assessed the quality of participants stories from the standpoint of DC while the Computation Measure assessed participants understanding of CT concepts. A customized scoring rubric was created for each of the two measures. For the Curation Measure, the assessment was comprised of five dimensions, including: (a) content selection, (b) content organization, (c) content originality, (d) content interactivity and (e) multimedia design. For the Computation Measure, the assessment was designed in alignment with the curriculum structure, including (a) event, (b) sequence, (c) conditionals, (d) variables and (e) loops. When calculating the scores, three experienced Scratch instructors were invited as raters to assess students' Scratch curation projects. To understand inter rater agreement, the Kendall's W was calculated for the two measures. For the Curation Measure, the Kendall's W is .83; for the CT Measure, the Kendall's W is .94. These values indicated a good inter-rater agreement was achieved for both measures among the three raters.

## Results

### Analysis of Students' Scratch Curation Projects

Even though all students were instructed to design an interactive story, it was found their final curation projects were quite diversified. To better illustrate the DC project created by students, we attempted to categorize all Scratch curation projects as the following genres: (a) narration (60%), (b) art gallery (18%), video games (7%) and others (15%). In Table 1, we found narration ($n$ = 21) was the most commonly seen genre created by students. Narration was defined as a story with discernible structural patterns, cause-and-effect sequence of events and development of characters. Aside from narration, 18% of students' Scratch curation project was identified as an art gallery (*n* = 6), meaning they exhibited a collection of artwork based on a specific theme. A video game (*n* = 3) was another genre (7%) in which students designed a simple, interactive video game with predefined game rules to follow. Lastly, there were 15% of students' curation fell into the others (*n* = 5) category as these Scratch projects were simply a display of random pictures that didn't belong to any of the above categories. A breakdown of students' Scratch curation projects was demonstrated in Table 1.

**Table 1 An Overview of Students' Scratch Curation Projects**

| Category | Percentage % | Descriptions |
|---|---|---|
| Narrative (*n* = 21) | 60 | A descriptive story with discernable details. |
| Art gallery (*n* = 6) | 18 | A collection of artwork based on a particular theme |
| Video game (*n* = 3) | 7 | A video game with predefined game rules to follow |
| Others (*n* = 5) | 15 | A visual display of random pictures |

## Analysis of the Curation Measure

The result of the Curation Measure was presented in Table 2. The mean score of students' overall Scratch curation skill was 2.71 out of 4, which fell between satisfactory and good according to the scoring rubric (see Appendix 1). Students achieved the highest mean score for the content selection dimension ($M$ = 3.23, $SD$ = 0.69) and the lowest score for the originality ($M$ = 1.57, $SD$ = 0.74) dimension. Overall, it was found students were rated as good (i.e., 3 points) for the content selection, organization and multimedia design dimension. The interactivity dimension was rated as satisfactory (i.e., 2 points) while the originality dimension was rated as poor (i.e., 1 points).

**Table 2 Results of the Curation Measure**

| DC / Scores | Content selection | Content organization | Content originality | Content interactivity | Multimedia design | Total |
|---|---|---|---|---|---|---|
| Mean (*SD*) | 3.23 (0.69) | 3.11 (0.63) | 1.57 (0.74) | 2.65 (1.05) | 3 (0.81) | 2.71 (0.99) |

In the meantime, a one-way ANOVA test was conducted to examine any significant differences among the five dimensions of the Curation Measure. The analysis indicated a significant difference when comparing the mean scores between each dimension, $F(4, 170) = 24.97$, $p < .01$. Post hoc analysis using the Turkey HSD test further revealed that the originality dimension was significantly lower than the other four dimensions ($p < .05$). In addition, the content selection dimension was significantly higher than the interactivity dimension ($p < .05$). No other significant differences were obtained from the analysis. A visual comparison of mean scores among the five dimensions was presented in Figure 3.

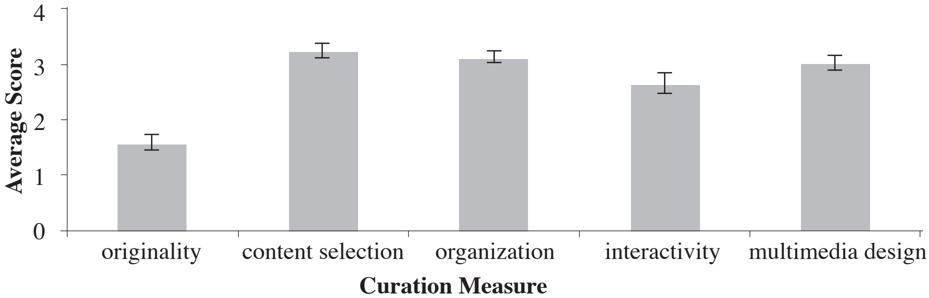


**Figure 3 Differences in Mean Scores between Each of the Diemension of Curation Measure**

Note: Error bars indicate the standard error of the mean.

## Analysis of the Computation Measure

The result of the Computation Measure was presented in Table 3. The overall mean score for learning CT concepts was 2.81, which fell between satisfactory and good to the scoring rubric (see Appendix 2). Students achieved the highest mean score for the event concept ($M = 3.11$, $SD = 0.82$) and the lowest mean score for the variables concept ($M = 2.45$, $SD = 0.85$). Overall, students were rated as good (i.e., 3 points) for more simple concepts such as the sequence and event and satisfactory (i.e., 2 points) for more sophisticated concept such as the conditionals, variables and loops concept.

**Table 3 Results of the Computation Measure**

| Scores \ CT concepts | Event | Sequence | Conditionals | Variables | Loops | Total |
|---|---|---|---|---|---|---|
| Mean<br>(*SD*) | 3.11<br>(0.82) | 3.05<br>(0.76) | 2.68<br>(0.87) | 2.25<br>(0.85) | 2.74<br>(0.74) | 2.81<br>(0.84) |

When further examined the differences in mean scores among the five CT concepts, a one-way ANOVA test showed a significant difference in mean scores, $F(4, 170) = 3.94$, $p < .05$. Post hoc analysis using the Turkey HSD test further revealed that both the result of event and sequence concept significantly outperformed the result of variables concept ($p < .05$). No other significant differences were obtained from the analysis. A visual comparison of mean scores among the five CT concepts was presented in Figure 4.

## Correlation Analysis between Curation Measure and Computation Measure

To examine the interrelationship between the Curation Measure and Computation Measure, a Pearson correlation analysis was performed. The analysis results indicated a non-significant correlation between the Curation Measure and Computation Measure, $r = .286$, $p = .095$. However, further investigations on correlations between each of the dimension within the Curation Measure and the Computation Measure indicated a significant positive correlation

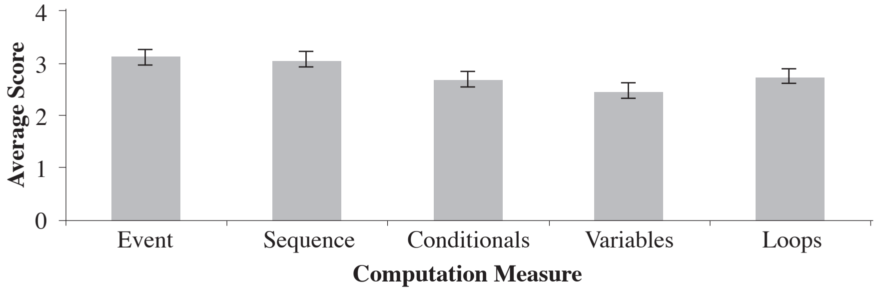


**Figure 4 Differences in Mean Scores between Each of the Diemension of Computation Measure**

Note: Error bars indicate the standard error of the mean.

under two conditions. In one condition, the analysis showed a significant positive correlation between the organization dimension of Curation Measure and the sequence concept of Computation Measure, $r = .535$, $p < .01$. In the other condition, the interactivity dimension of Curation Measure showed a significant positive correlation for the conditionals ($r = .779$, $p < .01$) and loops ($r = .598$, $p < .01$) concept. No other significant correlations were obtained from the analysis. Detailed results of correlation analysis between the Curation Measure and Computation Measure were presented in Table 4.

**Table 4 Correlation Analysis between Curation Measure and Computation Measure**

| Computation measure \ Curation measure | Content selection | Content organization | Content originality | Content interactivity | Multimedia design |
|---|---|---|---|---|---|
| Sequence | $r = .316$<br>$p = .065$ | $r = .535$<br>$p < .01$ | $r = .032$<br>$p = .854$ | $r = -.053$<br>$p = .763$ | $r = -.104$<br>$p = .554$ |
| Event | $r = .261$<br>$p = .130$ | $r = .030$<br>$p = .862$ | $r = -.061$<br>$p = .726$ | $r = -.088$<br>$p = .615$ | $r = -.132$<br>$p = .450$ |
| Conditionals | $r = -.319$<br>$p = .062$ | $r = -.309$<br>$p = .071$ | $r = -.262$<br>$p = .128$ | $r = .779$<br>$p < .01$ | $r = .169$<br>$p = .333$ |
| Variables | $r = .076$<br>$p =.701$ | $r = .064$<br>$p = .715$ | $r = -.287$<br>$p = .095$ | $r = .376$<br>$p = .060$ | $r = .129$<br>$p = .461$ |
| Loops | $r = -.227$<br>$p = .190$ | $r = -.124$<br>$p = .478$ | $r = -.207$<br>$p = .233$ | $r = .598$<br>$p < .01$ | $r = -.049$<br>$p = .778$ |

## Discussion

One might reasonably wonder why to investigate the interrelationship between the learning of CT and DC skills for children. Of course such skepticism was not completely unwarranted as the two skillsets appeared to vary by nature. In fact, this study was a reflection of previous research framework about teaching children CT practices with Scratch, in which researchers pointed out that children seemed more engaged in curating the multimedia content than in practicing the CT concepts during digital storytelling activities (Kafai et al., 2009). In other words, when guiding children to design an interactive story with Scratch, there were possibilities that the learning of CT and the learning of DC could interfere with each other, which in turn caused difficulties not only in instructional design but also in the attributions of educational outcomes. Our findings, in contrast, suggested that the learning of CT was not mutually exclusive to the learning of DC for children. Instead, the two skillsets could compliment each other in a number of aspects, such as the organization of the story's plot helped student practice the sequence concept of CT; the curation of interactive elements of the story helped students articulate how to appropriately apply conditionals and loops constructs to the design of the story. The following paragraphs first explored the results and implications of Curation Measure and Computation Measure, followed by intensive discussions on the interrelationship between CT and DC skills.

### Implications for Digital Curation Skills

The analysis of the digital curation (DC) project demonstrated that nearly 85% of the students completed a well-defined curation project using Scratch. Only 15% of students' Scratch projects lacked a theme that would connect personal experiences. In most students' projects, a cohesive sense of purpose was demonstrated. The percentage of completions was higher than expected because this workshop met only once a week for 10 sessions. When we investigated the types of curation projects, most were identified as narratives (60%) that had an articulated beginning, middle, and end for the reader to follow. Projects with an art gallery (18%) were the second most popular type; in them, students showcased their personal artwork. We found students were highly motivated to use the free drawing tools offered by Scratch to create their own clip art or audio recordings to convey their thoughts and ideas. A small number of students' curation works had a video game (7%), in which story ideas were transformed into either a contest or a puzzle with clearly defined game rules. Curation works that seemed to drift in many directions without a theme were categorized as other (15%).

Interestingly, though the same instructions and guidelines were given to all students, their curation projects varied greatly. Different children might have different perceptions about what constitutes a story. The variation in genres of curation also reflected the multimedia affordability and interactive elements offered by Scratch, which was consistent with findings in relevant studies (Kafai et al., 2009). Some students stayed focused on the narrative aspect of a story, others switched to the visual, aesthetic aspects of a story, and still others created entertaining elements for a story. To better illustrate how students curated an interactive story with Scratch, we summarized the core learning activities as a three-phase framework by referencing to the model proposed by Deschaine and Sharma (2015). First, DC began with active selection and filtering of multimedia resources in Scratch, a process through which a student learned to collect and filter out irrelevant data using cognitive learning procedures, such as critical thinking, problem solving, and self-reflection (Harvey, 2010). Next, students delved into the organization, arrangement, and evaluation of multimedia resources. This required a student to form a solid mental representation of the content to be curated by meticulously aligning the audience's expectations with his or her conceptual design plans. In the final phase, students demonstrated the content to be curated by coordinating multimodal representations, such as texts, images, audio clips, and animations (Porter, 2004).

Exploration of the mean scores of the five dimensions of Curation Measure (i.e., originality, content selection, story organization, interactivity, and media effect) suggested that digital storytelling with Scratch contributed to the understanding of children's DC skills in general. Digital storytelling served as an effective vehicle that helped students construct their knowledge through the learning by doing immersion method of constructivism (Yang & Wu, 2012). Students demonstrated better curation skills in the dimensions of content selection and story organization than in other dimensions. These two skills were considered fundamental to DC, particularly with the use of digital technologies (Hobbs, 2011; Mihailidis & Cohen, 2013). Besides, post-hoc analysis showing a significant difference between the content selection dimension and the interactivity dimension implied that it was more difficult to curate the interactivity of a story with block-based coding tools (BCTs). The interactivity dimension should be perceived as an interdisciplinary skill because it might involve knowledge in other domains, such as computer science. Meanwhile, students' performance in the multimedia design dimension revealed that they endeavored to integrate various media elements into the content in order to enhance the sensational experiences for the audience. It is worth noting that students had the lowest mean score for the originality dimension. Apparently, this was due to the influence of the entertainment media to which children are exposed every day; a huge portion of students' curation projects were reproductions of cartoons, movies, comic books, or video games that they often encounter. This caused us to try to further understand the potential effect of the entertainment media on children's DC skills in the future.

**Implications for Learning Computational Thinking Concepts**

Students' learning of computational thinking (CT) concepts during storytelling activities was examined through the framework of the five CT concepts (i.e., sequence, event, conditionals, loops, and variables). Using the overall mean score ($M$ = 2.81) as a cut-off value, we found that their performance in the event and sequence concepts was above the overall mean score, whereas their performance in concepts such as conditionals, variables, and loops was below the overall mean score. This implied that students demonstrated an understanding of CT concepts more on the comprehension aspect than on the generation aspect (Robins et al., 2003). These findings were consistent with relevant studies in which children struggled with understanding more advanced CT concepts, such as conditional statement and recursion (Fessakis, Gouli, & Mavroudi, 2013), because they tended to be abstract and lacked concrete representations from which students could develop a good mental model of computational constructs when breaking down a problem into an action plan (Pea & Kurland, 1984; Shneiderman, 1980). The event and sequence concepts were easier to comprehend because they were simple in computational structure and complexity. Students were able to trace and monitor the consequences of their actions in relation to the story narratives. In sum, understanding abstract CT concepts depended not only on one's mental representation but also on the ability to break a problem down into manageable chunks with reference to the story's plot.

Because the learning of CT concepts revolved around digital storytelling activities, we further analyzed the five CT concepts related to functionality in storytelling. The sequence and event concepts served as the foundation of the story in which the student assigned the character's position on the stage and set up navigation buttons. In addition, the student had to coordinate the timing of conversations or scene transitions, actions that were not easy for novices to achieve. The conditionals and loops concepts were responsible for the cause-and-effect relationships in the story narratives. These two concepts outlined the logical path of the story's plot and controlled the conceptual flow of the story. Because conditionals and loops are abstract constructs that might cause misconceptions in learning (Kaczmarczyk, Petrick, East, & Herman, 2010), we found students struggled with the inclusion of these judgment statements into their story narratives. It was notable that most students knew where and when to place a conditional construct but they failed to correctly drag and arrange the appropriate building blocks that would enable the conditional construct. The variable concept functioned as either a sensor or a data container that allowed the storyteller to interact with the audience. As a sensor, the audience could input data with a keyboard to actively participate in or respond to the story narrative. As a data container, the storyteller could collect contextual data to provide customized feedback when needed.

## The Interrelationship between CT and DC

The Pearson correlation analysis showed that the learning of CT concepts and the practice of DC appeared to develop independently of each other. There was no empirical evidence to support such a finding, because no previous studies had ever explored the interrelationships between the two abilities. Further investigation of the interrelationship between each of the dimensions within the two skills, however, guided us to uncover a possible conceptual linkage between the two seemingly different knowledge domains. For instance, a significant, positive correlation was reported between the organization dimension of the DC skill and the sequence concept of CT. This could be explained by the similarity between the two concepts because both of the evaluation criteria concentrated on the structural progression of a story. The organization dimension of DC evaluated students' abilities to organize the progression of a story plot. Likewise, the sequence concepts of CT examined students' ability to use the computational construct to support the ordering of events in a story. If a story had a well-organized structure during the process of DC, it would become easier for the storyteller to articulate the design of the computational constructs. To put it differently, the organization dimension represented the ability to conceptually organize a story, whereas the sequence concept represented the pragmatic skills needed to carry out the conceptual design plans. In this regard, a student's performance of CT skills could be explained by the student's performance of DC skills. A similar rationale was seen in the interactivity dimension of DC, where a significant, positive relationship was identified with the conditionals and loops concepts of CT. Given the fact that the design of both the conditionals and loops constructs controlled and determined the interactive mechanism of a story, it was reasonable that they would be significantly correlated with each other.

Henceforth, we argued that the learning of CT concepts and the practice of DC were in fact closely related to each other when engaging children in digital storytelling with a BCT such as Scratch. DC through digital storytelling could facilitate the learning of CT concepts under certain conditions. Additionally, the learning of CT and DC concepts could be perceived as a process of mental model construction through learning by doing. One's curation work could be perceived as a mental representation of a particular topic (Wolff & Mulholland, 2013) while one's understanding of a CT concept could be perceived as a mental representation of an abstract computational construct. These findings also shed light on instructional design practices in the sense that the learning and teaching of CT and DC skills should be regarded as one interdisciplinary skill that can be acquired by children. A common criticism of teaching novices computational constructs such as conditionals and variables is the lack of a rich, contextualized description of CT concepts (Gries, 2006; Gomes & Mendes, 2007; Veerasamy, D'Souza, & Laakso, 2016). The practice of DC, however, overcomes this drawback by situating students in a learning context where they can reflect on their personal experiences. Thus, the learning and teaching of abstract CT concepts, regardless of their functionality and complexity, should be framed in DC activities such as storytelling to more effectively motivate a student. In other words, the ideas of DC could serve as a road map that can guide the learning of CT concepts.

## Conclusion

This study aimed to understand the interrelationship between children's learning of CT concepts and the practice of DC because the learning of computational constructs seemed to overlap with the notion of curating a story. From analysis of the Curation Measure, we found students were most engaged in the content selection and story organization activities. Significant differences in mean scores between the five dimensions guided us to recognize students' insufficient knowledge when curating a story with Scratch. From analysis of the Computation Measure, students' learning performances were consistent with the level of difficulty of each CT concept. Though no significant difference was found in mean scores for each of the five CT concepts, students tended to struggle with integrating the more abstract, complex CT concepts (i.e., conditionals, loops, and variables) into digital storytelling activities. Further investigations revealed a significant, positive correlation between the content organization dimension and the design of sequence concept in CT. In addition, the content interactivity dimension was significantly correlated with the design of conditionals and loops constructs of CT. These findings led to an interdisciplinary collective perspective on the assessment of a student's learning of CT and DC practices. It was hoped that the learning of CT concepts would manifest itself in context of DC while the practice of DC would be strengthened by the inclusion of computational constructs.

There were a number of limitations in this study, and, based on these, further research suggestions were proposed as follows. One limitation of this study was the selection of CT concepts as we only focused on the five fundamental concepts. Further studies might expand the research scope by including more complex computational constructs to curate an interactive story. Next, since there were no Internet connections throughout the workshop, we didn't explore the content circulation aspect of DC skills. Further studies might attempt to investigate how students publish their Scratch curation projects online and reflect on the collected feedback to enhance their DC skills. A third limitation was the time and scheduling constraints. The study took place only once a week for 10 sessions whereas more frequent learning experiences and a longer duration of activities could result in finding more profound interrelationships between CT and DC. Lastly, though the same instructions were given to all students, we did not explicitly restrict the genre of the curation project to be a narrative story or not. Variations among different genres of DC might lead to different conclusions when interpreting the data. Future studies might seek to narrow down the scope by peeking into the interplay between CT and DC skills based on a particular genre of curation project.

## References

Adams, J. C., & Webster, A. R. (2012). What do students learn about programming from game, music video, and storytelling projects? In *Proceedings of the 43rd ACM Technical Symposium on Computer Science Education* (pp. 643-648). New York, NY: ACM. https://doi.org/10.1145/2157136.2157319

Albion, P. R. (2014). From creation to curation: Evolution of an authentic 'Assessment for Learning' task. In *Research Highlights in Technology and Teacher Education 2014* (pp. 69-78). Waynesville, NC: Association for the Advancement of Computing in Education.

Barr, V., & Stephenson, C. (2011). Bringing computational thinking to K-12: What is involved and what is the role of the computer science education community? *ACM Inroads*, *2*(1), 48-54. https://doi.org/10.1145/1929887.1929905

Beagrie, N. (2006). Digital curation for science, digital libraries, and individuals. *The International Journal of Digital Curation*, *1*(1), 3-16. https://doi.org/10.2218/ijdc.v1i1.2

Boon, T. (2011). Co-curation and the public history of science and technology. *Curator: The Museum Journal*, *54*(4), 383-387. https://doi.org/10.1111/j.2151-6952.2011.00102.x

Bratitsis, T., & Ziannas, P. (2015). From early childhood to special education: Interactive digital storytelling as a coaching approach for fostering social empathy. *Procedia Computer Science*, *67*, 231-240. https://doi.org/10.1016/j.procs.2015.09.267

Brennan, K., & Resnick, M. (2012). *New frameworks for studying and assessing the development of computational thinking*. Paper presented at the 2012 Annual Meeting of the American Educational Research Association, Vancouver, Canada.

Burke, Q., & Kafai, Y. B. (2010). Programming & storytelling: Opportunities for learning about coding & composition. In *Proceedings of the 9th International Conference on Interaction Design and Children* (pp. 348-351). New York, NY: ACM. https://doi.org/10.1145/1810543.1810611

Connelly, F. M., & Clandinin, D. J. (1990). Stories of experience and narrative inquiry. *Educational Researcher*, *19*(5), 2-14. https://doi.org/10.3102/0013189X019005002

Cowick, C. (2018). *Digital curation projects made easy: A step-by-step guide for libraries, archives, and museums*. Lanham, MD: Rowman & Littlefield.

Creamer, A., Morales, M. E., Crespo, J., Kafel, D., & Martin, E. R. (2012). An assessment of needed competencies to promote the data curation and data management librarianship of health sciences and science and technology librarians in New England. *Journal of eScience Librarianship*, *1*(1), 18-26. https://doi.org/10.7191/jeslib.2012.1006

Dale, S. (2014). Digital curation: The future of relevance. *Business Information Review*, *3*(4), 199-205. https://doi.org/10.1177/0266382114564267

Deschaine, M. E., & Sharma, S. A. (2015). The five Cs of digital curation: Supporting twenty-first-century teaching and learning. *InSight: A Journal of Scholarly Teaching*, *10*, 19-24.

Erickson, T. (1996). Design as storytelling. *Interactions*, *3*(4), 30-35. https://doi.

org/10.1145/234813.234817

Fessakis, G., Gouli, E., & Mavroudi, E. (2013). Problem solving by 5-6 years old kindergarten children in a computer programming environment: A case study. *Computers & Education*, *63*, 87-97. https://doi.org/10.1016/j.compedu.2012.11.016

Fotopoulou, A., & Couldry, N. (2015). Telling the story of the stories: Online digital curation and digital engagement. *Information, Communication & Society*, *18*(2), 235-249. https://doi.org/10.1080/1369118X.2014.952317

Gomes, A., & Mendes, A. J. (2007). *Learning to program — Difficulties and solutions*. Paper presented at International Conference on Engineering Education — ICEE 2007, Coimbra, Portugal. Retrieved from http://icee2007.dei.uc.pt/proceedings/papers/411.pdf

Gottschall, J. (2013). *The storytelling animal: How stories make us human*. New York, NY: First Mariner Books.

Gries, D. (2006). What have we not learned about teaching programming? *Computer*, *39*(10), 81-82. https://doi.org/10.1109/MC.2006.364

Grover, S., & Pea, R. (2013). Computational thinking in K-12: A review of the state of the field. *Educational Researcher*, *42*(1), 38-43. https://doi.org/10.3102/0013189X12463051

Guzdial, M. (2008). Education: Paving the way for computational thinking. *Communications of the ACM*, *51*(8), 25-27. https://doi.org/10.1145/1378704.1378713

Harvey, R. (2010). *Digital curation: A how-to-do-it manual*. New York, NY: Neal Schuman.

Hobbs, R. (2011). *Digital and media literacy: Connecting culture and classroom*. Thousand Oaks, CA: Corwin.

Howell, D. D., & Howell, D. K. (2003). *Digital storytelling: Creating an eStory*. Worthington, OH: Linworth

Isbell, R., Sobol, J., Lindauer, L., & Lowrance, A. (2004). The effects of storytelling and story reading on the oral language complexity and story comprehension of young children. *Early Childhood Education Journal*, *32*(3), 157-163. https://doi.org/10.1023/B:ECEJ.0000048967.94189.a3

Kaczmarczyk, L. C., Petrick, E., East, J. P., & Herman, G. L. (2010). Identifying student misconceptions of programming. In *Proceedings of the 41st ACM Technical Symposium on Computer Science Education* (pp. 107-111). New York, NY: ACM. https://doi.org/10.1145/1734263.1734299

Kafai, Y. B. (2016). Education from computational thinking to computational participation in K-12 education seeking to reframe computational thinking as computational participation. *Communications of the ACM*, *59*(8), 26-27. https://doi.org/10.1145/2955114

Kafai, Y. B., Peppler, K. A., & Chapman, R. N. (Eds.). (2009). *The computer clubhouse: Constructionism and creativity in youth communities*. New York, NY: Teachers College Press.

Kurland, D. M., Pea, R. D., Clement, C., & Mawby, R. (1986). A study of the development of programming ability and thinking skills in high school students. *Journal of Educational Computing Research*, *2*(4), 429-258.

Lye, S. Y., & Koh, J. H. L. (2018). Case studies of elementary children's engagement in computational thinking through scratch programming. In M. Khine (Ed.), *Computational* *thinking in the STEM disciplines* (pp. 227-251). Cham, Switzerland: Springer.

MacDonald, M. R. (Ed.). (1998). *Traditional storytelling today: An international sourcebook*. Chicago, IL: Fitzroy Dearborn.

Mihailidis, P., & Cohen, J. N. (2013). Exploring curation as a core competency in digital and media literacy education. *Journal of Interactive Media in Education*, *2013*(1), Art. 2. https://doi.org/10.5334/2013-02

Moen, T. (2006). Reflections on the narrative research approach. *International Journal of Qualitative Methodology*, *5*(4), 56-69. https://doi.org/10.1177/160940690600500405

Molloy, L. (2014). Digital curation skills in the performing arts: An investigation of practitioner awareness and knowledge of digital object management and preservation. *International Journal of Performance Arts and Digital Media*, *10*(1), 7-20. https://doi.org/10.1080/14794713.2014.912496

Niemi, H., Harju, V., Vivitsou, M., Viitanen, K., Multisilta, J., & Kuokkanen, A. (2014). Digital Storytelling for 21st-century skills in virtual learning environments. *Creative Education*, *5*(9), 657-671. https://doi.org/10.4236/ce.2014.59078

O'Neill, M. (2006). Essentialism, adaptation and justice: Towards a new epistemology of museums. *Museum Management and Curatorship*, *21*(2), 95-116. https://doi.org/10.1080/09647770600302102

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas*. New York, NY: Basic Books.

Pea, R. D., & Kurland, D. M. (1984). On the cognitive effects of learning computer programming. *New Ideas in Psychology*, *2*(2), 137-168. https://doi.org/10.1016/0732-118X(84)90018-7

Porter, B. (2004). *DigiTales: The art of telling digital stories*. Sedalia, CO: Bernajean Porter.

Psomos, P., & Kordaki, M. (2012). Pedagogical analysis of educational digital storytelling environments of the last five years. *Procedia: Social and Behavioral Sciences*, *46*, 1213-1218. https://doi.org/10.1016/j.sbspro.2012.05.277

Robins, A., Rountree, J., & Rountree, N. (2003). Learning and teaching programming: A review and discussion. *Computer Science Education*, *13*(2), 137-172. https://doi.org/10.1076/csed.13.2.137.14200

Rule, L. (2010). Digital storytelling: Never has storytelling been so easy or so powerful. *Knowledge Quest*, *38*(4), 56-57.

Sadik, A. (2008). Digital storytelling: A meaningful technology-integrated approach for engaged student learning. *Educational Technology Research and Development*, *56*, 487-506.

Shneiderman, B. (1980). *Software psychology: Human factors in computer and information systems*. Cambridge, MA: Winthrop.

Soloway, E. (1986). Learning to program = Learning to construct mechanisms and explanations. *Communications of the ACM*, *29*(9), 850-858.

Veerasamy, A. K., D'Souza, D., & Laakso, M.-J. (2016). Identifying novice student programming misconceptions and errors from summative assessments. *Journal of Educational Technology Systems*, *45*(1), 50-73. https://doi.org/10.1177/0047239515627263

Voogt, J., Fisser, P., Good, J., Mishra, P., & Yadav, A. (2015). Computational thinking in compulsory education: Towards an agenda for research and practice. *Education and Information Technologies*, *20*(4), 715-728. https://doi.org/10.1007/s10639-015-9412-6

Wilson, A., Hainey, T., & Connolly, T. M. (2013). Using scratch with primary school children: An evaluation of games constructed to gauge understanding of programming concepts. *International Journal of Games-Based Learning*, *3*(1), 93-109.

Wing, J. M. (2006). Computational thinking. *Communications of the ACM*, *49*(3), 33-35. https://doi.org/10.1145/1118178.1118215

Wing, J. M. (2008). Computational thinking and thinking about computing. *Philosophical Transactions of the Royal Society*, *366*(1881), 3717-3725. https://doi.org/10.1098/rsta.2008.0118

Wolz, U., Stone, M., Pearson, K., Pulimood, S. M., & Switzer, M. (2011). Computational thinking and expository writing in the middle school. *ACM Transactions on Computing Education*, *11*(2), Article 9. https://doi.org/10.1145/1993069.1993073

Xinogalos, S. (2012). An evaluation of knowledge transfer from microworld programming to conventional programming. *Journal of Educational Computing Research*, *47*(3), 251-277. https://doi.org/10.2190/EC.47.3.b

Yang, Y.-T. C., & Wu, W.-C. I. (2012). Digital storytelling for enhancing student academic achievement, critical thinking, and learning motivation: A year-long experimental study. *Computers & Education*, *59*(2), 339-352. https://doi.org/10.1016/j.compedu.2011.12.012

# Appendix 1

## Curation Measure Scoring Rubric

| Category \ Points | 0 (Unacceptable) | 1 (Poor) | 2 (Satisfactory) | 3 (Good) | 4 (Excellent) |
|---|---|---|---|---|---|
| Content Selection | No specific theme of curation was defined. | A theme could be roughly identified and the content lacked coherence. | A theme was clearly identified but not well-maintained. | A theme was clearly identified and mostly maintained a focus. | A theme was clearly identified with a coherent focus throughout the curation. |
| Content Organization | A beginning, middle or end of the story was missing. No important plot elements. | Part of a beginning, middle or end of the story was created. No important plot elements. | A clear beginning, middle and end were created. No important plot elements. | A clear beginning, middle and end were created with some important plot elements. | A clear beginning, middle and end were created with all plot elements in detail. |
| Content Originality | The content was not original at all. | The content was partially original with minimal modifications. | The content was partially original with major modifications. | The content was original and uniquely presented. | The content was original and exceptionally unique. |
| Content Interactivity | No interactive story narrations were added. | Attempted to add interactive story narrations but didn't match the story's plot. | Interactive story narrations were created to match some parts of the story's plot. | Interactive story narrations were created to match most parts of the story's plot. | Interactive story narrations were properly created for the entire story's plot. |
| Multimedia Design | No multimedia element (i.e., visual effects, animations or sound clips) was seen. | Added multimedia elements but the design of effect was not understandable. | Multimedia elements were adequately added to enrich some parts of the story. | Multimedia elements were correctly added to enrich most parts of the story. | A well-planned selection of multimedia element was made to enrich the whole story. |

# Appendix 2

## Computation Measure Scoring Rubric

| Concepts \ Points | 0 (Unacceptable) | 1 (Poor) | 2 (Satisfactory) | 3 (Good) | 4 (Excellent) |
|---|---|---|---|---|---|
| Event | No event blocks were found on the stage. | Dragged event blocks but attached nothing to them. | Added event blocks but were attached to the incorrect characters. | Correctly added event blocks to characters but had redundant blocks. | Correctly added event blocks without any errors. |
| Sequence | No sequence blocks were found on the stage. | Dragged sequence blocks but attached nothing to them. | More than 3 programming errors were found for the sequence blocks. | Only 1-3 programming errors were found for the sequence blocks. | Correctly added sequence blocks without any errors. |
| Conditionals | No conditionals blocks were found on the stage. | Dragged conditionals constructs but attached nothing to them. | More than 3 programming errors were found within the conditional constructs. | Only 1-3 programming errors were found within the conditional constructs. | The conditionals constructs were correctly created without any errors. |
| Variables | No variables blocks were found on the stage. | Created variables blocks but attached nothing to them. | More than 3 programming errors were found within the variables construct. | Only 1-3 programming errors were found within the variables construct. | The variables construct was created correctly without any programming errors. |
| Loops | No loops blocks were found on the stage. | Dragged loops blocks but attached nothing to them. | More than 3 programming errors were found within the loops construct. | Only 1-3 programming errors were found within the loops construct. | The loops construct was created correctly without any errors. |

Chun-Hao Chang ORCID 0000-0002-6009-6521

教育資料與圖書館學　56 : 1 (2019) : 45-68
DOI:10.6120/JoEMLS.201903_56(1).0033.RS.CE

研究論文

# 兒童學習運算思維概念與數位策展能力的關聯性研究初探

張君豪

## 摘要

透過Scratch進行數位敘事，是培養兒童運算思維常見的教學模式。兒童在透過數位敘事學習運算思維概念時，也同時啟發了數位策展能力的培養，但在學習成效評測時，相關研究多聚焦於運算思維概念而非數位策展能力，對於兩種能力間的互動關係也缺乏探究。鑑於此，本研究以紐約市35位五年級生為例，在10週的學習中，剖析他們使用Scratch設計互動故事時，在運算思維概念與數位策展能力之間的學習成果，並針對運算思維的五個子概念與數位策展的五個子維度，進行相互的關聯性分析。統計結果顯示，雖然運算思維概念與數位策展能力整體而言並無顯著關聯性，但在子維度的分析上，發現數個具有顯著關聯性的情境，可供教學設計時參考。

**關鍵詞：**運算思維，數位策展，數位敘事，Scratch，K-12教育

國立臺灣師範大學資訊工程學系博士後研究員
E-mail: chunhao.chang@tc.columbia.edu