Using Visual Methods to Explore How Students in Information-Related Fields Express the Concept of "Information"

Tien-I Tsai
Assistant Professor
Department of Library and Information Science, National Taiwan University

titsai@ntu.edu.tw

Abstract

This study used a visual method to explore how 219 undergraduate and master's students in library and information science, information management, and computer science perceive the concept of "information" through drawing and writing. Through content analysis, the researcher examined the elements and meanings appeared in the participant-drawn pictures, namely, the iSquares. The findings showed that while types of iSquares are somewhat similar among students from different fields of study, the elements used to express the concept of information are quite different. The complexity of the compositions and the perspectives are also different. Students in library and information science tend to use more complex compositions, and include the image of people and print materials as elements in their iSquares. They tend to use various metaphors to express the concept of information, and address issues related to uncertainty, information seeking process, or information hierarchy. In contrast, students in information management tend to address issues related to big data, and students in the computer science tend to present the concept of information with a relatively simple composition including tools and equipment. Based on the findings, the current study provides pedagogical and research suggestions.

Keywords: *Visual methods, Information science, College students, Information*

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以視覺方法探討資訊相關領域學生如何表述「資訊」概念

蔡天怡
國立臺灣大學圖書資訊學系助理教授

titsai@ntu.edu.tw

摘要
本研究運用「資訊方塊」（iSquares）之視覺研究方法，以受試者所產製的圖文，探討來自圖書資訊學、資訊管理學及資訊工程學系所 219 位大學生及碩士生所感知的資訊概念。透過內容分析法檢視其圖像元素與意涵，研究發現來自不同系所之學生所繪製之資訊方塊類型分布情形有些相似，然其用以表述資訊之元素繁簡程度不一，切入點亦有所不同。圖書資訊領域學生傾向以較複雜的構圖，運用人或人的意象、紙本或印刷品、各種比喻來表述資訊概念，並表達不確定性、資訊尋求的過程與資訊階層等內涵。相形之下，資訊管理領域學生則傾向表達資料處理與巨量資料之概念，而資訊工程領域學生傾向以較簡單的構圖或工具與設備來呈現資訊之概念。本研究據此提出教學相關實務建議與未來研究建議。

關鍵詞：視覺方法，資訊科學，大學生，資訊

Introduction

Individuals interact with information every day. Students in information-related fields not only interact with information for everyday-life purposes but also tackle the issues regarding information in their coursework and research. According to the list of departments in higher education from the Ministry of Education (2019), the major fields of study related to information include library and information science (LIS), information management (IM), and computer science (CS). Among them, the field of library and information science comes from the traditional library science with the development of science and technology, focusing on the creation, collection, organization, preservation, and dissemination of various information (Hu, Wang, 2003; Lai, 2001; Department of LIS at National Taiwan University, 2019); the field of information management has evolved with the development of science and technology, mainly focusing on the application of information systems to assist management, as well as the management of information systems (Department of Information Management at National Taiwan University, 2019); the field of computer science focuses on development and application of information technology (Department of Computer Science & Information Engineering at National Taiwan University, 2019).

Although students and scholars in all these disciplines study "information," they may study information from very different perspectives. Navigating through fundamental textbooks and syllabi of information-related fields (National Taiwan University, n.d.), the concept of information is mostly briefly discussed. Despite that library and information science courses may spend a unit on the topic of "information," information management and computer science courses typically dive into the structure or the application of information. Examining how students in the above three fields view "information" may not only help us better understand perceptions of students' with different types of training but also illustrate the concept of information in fuller ranges.

"iSquare" developed by Hartel since 2011 (Hartel, 2012) is a visual method to study how people perceive the concept of information; it is, at the same time, a pedagogy to help instructors address this concept. Hartel (2014a; 2014b) used this draw-and-write technique asking students to express the concept of "information" through drawing on a small square blank paper with a brief textual description on the back side of the paper; these studies discussed images based on Engelhardt's (2002) types of graphic presentations and analyzed information behavior concepts appearing when students present the concept of information. More recently, Hartel tried to examine iSquares with different data analysis methods. Hartel (2015, 2017) proposed four methods for analyzing iSquares; Hartel and Savolainen (2016) discussed iSquares with pictorial metaphor analysis. Hartel, Noone, Power, Danzanov, and Kelly (2017) discussed the implementation of iSquares and proposed specific data collection and analysis methods for iSquares research. This draw-and-write technique has also been applied to different cultural settings (e.g., Ibekwe-SanJuan, 2017; Tsai, 2015) and used to explore other concepts (e.g., Ibekwe-SanJuan, 2018).

iSquare research is growing but still in its developing stages. Based on Hartel (2014a), Tsai (2015) attempted to use this visual method to explore the information stories of 56 LIS students. The study used thematic analysis to examine the elements appeared (e.g., image of people, media and tools, the nature and other contextual elements) and the concepts presented on iSquares (such as information theory and the concept of information behavior, the characteristics of huge amounts of data); based on the themes appearing in the iSquares, stories of information were illustrated in four different ways: 1. from micro-social to macro-social/from imperceptibly small to vast, as suggested by Hartel (2014a); 2. from concrete descriptions to abstract metaphors/from external to internal; 3. from static to mobile/from trickling to rapid; 4. from unorganized to organized/uncertain to confident. The current study aims to extend relevant studies and examine how students in information-related fields perceive the concept of information through drawing and writing on the iSquares, as well as how similar or different their iSquares are. The research questions include:

1. How do students in information-related fields express the concept of "information" through drawing and writing?
2. How similar or different are the elements used in students' iSquares across information-related fields? And how similar or different are their perspectives?

Literature Review

In order to delineate how to approach the fundamental question of "what is information" through iSquare as a visual method, the literature review starts from defining the concept of information based on dictionaries and textbooks in information-related fields, followed by iSquare as a visual method and the current state of relevant empirical studies in the field of LIS.

Defining the concept of information

Information is a common vocabulary in our daily lives, but it is one that "being used widely but inaccurately" (Wang & Hsieh, 2014, p. 5). According to Wang and Hsieh, information is a collection of statements, opinions, facts, concepts, or ideas between the raw data and knowledge; it can be any processed data and is often obtained through communication, research, teaching, observation, and so on. Tsai (2015) also pointed out that most dictionaries do not distinguish the concepts of data, information, and knowledge, and define information in a simple but general way, except for a few emphasizes that information need to be processed or helpful to individuals. For instance, *Longman Dictionary of Contemporary English* and *Cambridge English Dictionary* focus more on the factual information; *Collins English Dictionary*, *Merriam-Webster Dictionary*, and *Oxford English Dictionary* emphasize knowledge learned and experienced.

Interestingly, when investigating the definition of information from the textbooks of information-related fields, we can easily see different emphases in the three information-related fields. Many LIS textbooks introduce the DIKW hierarchy when defining information, and the textbooks also discuss different perspectives of information (e.g., Lai, 2001; Wang & Hsieh, 2014). Some also introduce Buckland's (1991) perspectives when discussing the nature of information—information as process, information as knowledge, and information as thing, and distinguish the idea of tangible versus intangible, entity versus process (e.g., Lai, 2001). Buckland's information-as-process focuses on the intangible process of cognitive change, or the process of messages delivering through physical items such as books or documents. Information-as-process focuses on the intangible process of cognitive change, or the process of messages delivering through physical items such as books or documents. Information-as-knowledge focuses on the intangible nature of information, emphasizing what information intellectually giving to people. Information-as-thing focuses on the tangible nature of information, emphasizing the physical object itself such as books or documents. Other LIS textbooks also discuss information from a viewpoint of communication by introducing Shannon and Weaver's (1948) classic work, emphasizing that messages are delivered from a sender to a receiver through a certain channel. (e.g., Lai, 2001; Debons, 2008; Bawden & Robinson, 2013).

On the contrary, IM and CS textbooks typically spend much less emphasis on introducing the concept of information. Several IM textbooks define information as meaningful and useful messages that are transformed or processed from data (Chen, 2004; Chu, 2017; Loudon & Loudon, 2012). These textbooks tend to emphasize the linear procedure turning raw data into meaningful information with a few sentences to make this simple distinguish, and focus more on information systems and information technologies while introducing the basic concepts of information management. Others do not provide formal definitions or discussions regarding the concept of information (e.g., Wu, 2015; Lin, 2010; Hsieh & Wu, 2009). In CS textbooks, they typically don't formally define information and dive into concepts regarding data type, data structure, algorithm, hardware, and so on (e.g., Cormen, et al., 2009; Karumanchi, 2017). These different emphases may help us better understand students' perceptions on information later in the discussion section.

Visual methods and iSquare research

Visual methods can be all uses of images for research, with or without accompanying words and whether pre-existing or generated as part of the research process (Payne & Payne, 2004). The images can either be pictures, photographs, video, or film, etc., and a simple classification can be made based on the source of images—1. images produced by the researcher, and 2. images produced or found by the participants (Jupp, 2006). According to Jupp, visual methods offer the knowledge that cannot be communicated verbally or in written words, and add a new dimension to qualitative research. Research that employs visual methods relies on collecting and analyzing visual data such as drawings, photos, videos, films, and visual arts (Banks, 2007, 2008; Spencer, 2010). When using visual methods to explore a specific concept, participant-draw pictures are often used; this approach has been used a lot on school children and can also be applied to different populations ranging from college students, adults, and the elderly (Copeland & Agosto, 2012).

In the field of LIS, an increasing number of studies have been applying in many different ways recently (Hicks & Lloyd, 2018). Hicks and Lloyd also pointed out that applying visual methods can help to bring up more in-depth discussions in the field. Compared to other fields in social sciences, the use and development of visual methods in LIS research happened relatively late. It is not until the recent decade that visual methods received attention, and Hartel's iSquares can be seen as one of the important recent starts of using visual methods in LIS research.

In 2011, Hartel developed iSquares as a pedagogical approach and a research approach to explore how students perceive the concept of information (Hartel, 2012). It is a visual method with participant-drawn images with texts but without verbal narratives (Hartel, 2014a). Hartel (2014a) used this draw-and-write technique to explore the same question—what is information—with 137 iSchool graduate students and examined each iSquare and categorized them with different types of graphic representation based on Engelhardt (2002). Hartel found these iSquares were composed mainly in picture, link diagram, and grouping diagram. Hartel (2014b) then focused on the information behavior concept addressed in 293 iSquares from graduate students in information and museum studies. Through deductive theme analysis, Hartel (2014b) examined information behavior concepts appearing in the iSquares, and found that print artifacts, information technologies, abstractions and patterns, symbols, and the nature were used to express the idea. Images of people were presented through hands, the brain, a person thinking, a twosome in information exchange, and an information-rich social world.

Tsai (2015) attempted to explore students' perceptions of information through iSquares with 56 LIS students. The study used thematic analysis to examine the elements appearing in the iSquares and identified three main categories: 1. Image of people, 2. media and tools, 3. the nature and contextual elements. Meanwhile, the perspectives based on Buckland's (1991) views of information and the concept of information behavior, as well as characteristics of big data (i.e., volume, velocity, and variety) were also identified to form four different versions of information stories.

More recently, Hartel (2015) proposed four methods for analyzing iSquares, including compositional interpretation, thematic analysis, content analysis, and pictorial metaphor analysis. However, it is a brief conference abstract without details. Hartel and Savolainen (2016) further discussed the concept of information using iSquares with pictorial metaphor analysis, and found iSchool students used a wide variety of elements in the metaphor—the earth, net, tree, light bulb, box/box, cloud, seed, sun, ocean/boat, fishing/mining. Hartel (2017) then developed the iSquare protocol with its detailed procedure, and reiterate the four data analysis methods for iSquare research. Specifically, an example of ongoing International iSquare research with content analysis was introduced. The coding scheme were also introduced, and items in the coding scheme included print artifacts, information behavior, ICTs, information structures and organizations, and the settings.

Overall, iSquare research using participant-drawn images as a visual method has been mostly conducted with students in LIS/iSchool. While different data analysis methods have been applied in empirical research for different purposes, on-going content analysis iSquare research seemed to be still underway and require further endeavors to expand iSquare research. The current study developed a codebook for content analysis based on the above literature so that iSquares from students with different backgrounds can be easily compared.

Methods

The purpose of the current study is to examine how students perceive the concept of "information" through drawing and writing. An arts-informed qualitative method was used to collect data. In order to systematically compare and contrast students' perceptions across three information-related fields, content analysis was used to analyze the data.

Data collection

The current study used a visual method—iSquares—to explore the concept of information perceived by 219 undergraduate and graduate students from the

Department of Library and Information Science, Information Management, and Computer Science & Information Engineering at a large public research university in Northern Taiwan. With instructors' permissions, students were recruited from a required course from each department. As suggested by Hartel, the best occasion for an iSquare activity is in classroom settings. Therefore, the researcher scheduled a time with the instructors and collected the iSquares in the above courses.

This study follows Hartel's (2014) iSquare protocol and used iSquare as the research instrument. A 4.25 square-inch white drawing paper with one blank side and the other printed instructions. Students were briefly introduced with the research, and then asked to use approximately ten minutes to draw on the blank side and describe their drawings with texts, as well as answer the demographic questions, including gender, age, and program, on the reverse side. To ensure the reliability of the current study, the researcher also provided black pens to the students with the iSquare paper. The researcher finally concluded the activity and finished the data collection procedure. Additionally, the researcher also kept field notes for each iSquare activity for each course.

Participants

Students who participated in the current study included 138 undergraduate and 81 graduate students from the Department of Library and Information Science (31.05%), Information Management (33.33%), and Computer Science & Information Engineering (35.62%) (see Table 1). While most LIS students are female (80.6%), more IM students are male (66.7%), and CS students are mostly male (86.5%). The gender distribution roughly reflects the student population in each department. As to the age, almost all students are between 19 and 25 (93.61%) with an average of 21.67 (*SD*=2.98).

Table 1　Participants' Demographics (*N*=219)

Demographics		Number of Participants	Percentage (%)
Gender	Male	125	57.08
	Female	88	40.18
	Choose not to identify	6	2.74
Age	19-20	103	47.03
	21-22	54	24.66
	23-25	47	21.46
	Over 25	12	5.48
	Blank	2	.91
Field of Study	Library and Information Science (LIS)	68	31.05

Demographics		Number of Participants	Percentage (%)
	Information Management (IM)	73	33.33
	Computer Science (CS)	78	35.62
Level of Study	Undergraduate	138	63.01
	Graduate (Master's level)	81	36.99

Data analysis

Content analysis is a systematic approach, which aims to analyze the content characteristics of data quantitatively, and to some extent, can reach inferences beyond descriptive analysis (Neuendorf, 2002). It can systematically examine and compare the contents appearing in visual data (Rose, 2007), including iSquares (e.g., Hartel, 2015; 2017). The purpose of this study is to explore how students in information-related fields perceive and present the concept of "information." Through content analysis, iSquares from the three departments can be systematically compared and contrast. While data analysis was conducted mainly based on the drawings, supplemented by text, the unit of analysis is the iSquare by each student. All information on each iSquare (both drawings and texts) by each student was viewed as one unit.

The codebook of the current study was developed mainly based on previous studies (Hartel, 2014b; Tsai, 2015) and the International iSquare Study (http://www.isquares.info/international-isquare-study.html). In addition to the demographics (i.e., gender, age, program, degree), the codebook with 25 questions was divided into two major parts: 1. composition and elements; 2. perspectives and meanings of the information concept. Regarding the composition, basic types of graphic presentations are based on the ten categories proposed by Engelhardt (2002), and other composition and element questions came from the International iSquare Study and Hartel (2017); the perspectives and meanings are mainly derived from the findings of Tsai (2015) and the International Study.

As to the graphic presentation, each iSquare was categorized into one specific graphic presentation (e.g., picture, link diagram, or grouping diagram) according to its major composition. If the iSquare drawing contains multiple graphic presentations (such as groups, links and texts), the texts on the other side of the iSquare would be used to help identify the major composition. Figure 1 presents the iSquares that were identified as the three major graphic presentations—pictures, link diagrams and grouping diagrams.

Pictures | Link Diagrams | Grouping Diagrams

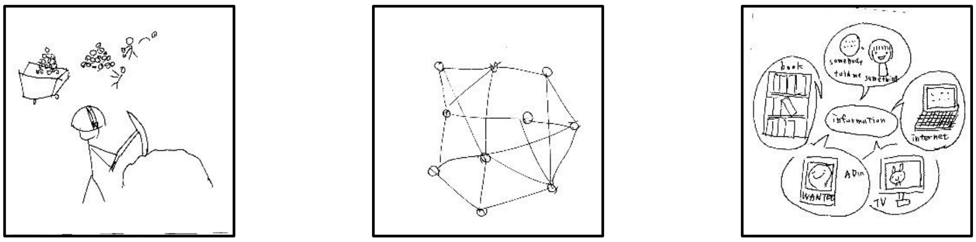


Figure 1 Three Major Types of iSquare Graphic Presentations

According to Tsai (2015), three major elements appearing in LIS students' iSquares include: 1. the image of people, 2. media and tools, 3. the nature and other contextual elements. In order to be more specific to develop the codebook for content analysis, the current study used "information and communications technology (ICT)" and "print materials/artifacts" instead of "media and tools." And used "scenes" instead of "the nature and other contextual elements." When coding the elements in the iSquares, the researcher looked into the drawing to identify the aforementioned elements, and then consult the texts on the other side to make sure it was accurately interpreted. When coding the perspectives and meanings of the information concept, the researcher relied even more on the texts to ensure not over interpreting the iSquares.

The study codebook has undergone three major revisions and several minor adjustments. During the three revisions, approximately 5%, 8%, and 10% of total iSquares (i.e., 12, 18, and 21 iSquares) were sampled for codebook testing. Testing samples were evenly distributed from each discipline (i.e., 4, 6, 7 each). The researcher and two other coders with LIS background conducted the pre-tests. According to Kassarjian (1977), the ideal inter-coder reliability should be greater than 85%. The inter-coder reliability of current study increases from the initial 83% to 92%. Chi-square tests were conducted for each item to see whether or not students from different disciplines present their iSquares differently.

Findings

The iSquares collected in the current study were analyzed based on their compositions, elements, perspectives and meanings, as described in the Methods section. Findings regarding how similar or different regarding the elements appearing in the iSquares and the perspectives and meanings are described as follows:

Compositions of the iSquares

The current study examined the type and complexity of the compositions of the iSquares across disciplines. No significant difference was found in the type of iSquares. Students in all information-related fields typically used pictures or link diagrams to depict the concept of information, and some used either grouping diagrams or written texts (Table 2). Nevertheless, the complexity of iSquares created by students in different fields are very different ($\chi^2(4, N=219)=42.786, p<.001$).

Table 2 Composition of iSquares across Information-Related Fields

Composition	Field of Study	Distribution
Type	LIS	Picture = Link Diagram > Grouping Diagram > Written Text > Symbol *Note: no blank iSquare*
	IM	Picture > Link Diagram > Written Text > Grouping Diagram > Symbol = Blank
	CS	Picture > Link Diagram > Written Text > Grouping Diagram > Symbol > Blank
Complexity***	LIS	**High** = Medium > Low
	IM	**Medium** > Low > High
	CS	**Low** > Medium > High

Note 1: ***$p<.001$

Note 2: LIS represents library and information science; IM represents information management; CS represents computer science.

As to the types of iSquares, most students used pictures (43.8%) or link diagrams (28.8%) as the main composition. While Tsai (2015) and Hartel (2014a) were conducted only with students in the department of LIS and iSchool, the overall distribution in the current study is somewhat similar to the findings of Tsai (2015) and Hartel (2014a) (see Table 3). The majority of the students used either pictures or link diagrams to present the iSquares. LIS students in the current study especially liked to use link diagrams; IM and CS students seemed to prefer written texts.

Although no significant difference was found in types of iSquares across disciplines, IM and CS students shared some similarity, whereas LIS students are unique among the three groups of students. For instance, the percentages of students who used written texts doubled those who used grouping diagrams in both IM and CS (IM 13.7% written texts vs. 6.8% grouping diagrams; CS 20.5% vs. 10.3%). There are also a few valid blank iSquares (with a textual explanation on the back side of their iSquares) from IM and CS students. In contrast, more LIS students (39.7%) than other students (IM 24.7%, CS 23.1%) used link diagrams, and grouping diagrams (10.3%) appeared more than written texts (7.4%) among LIS students. And no LIS students left their iSquares blank.

Table 3 Type of iSquares in the Current Study and Relevant Studies (all in %)

Type of iSquares	All students in current study (*N*=219)	LIS students in current study (*n*=68)	LIS undergraduate students in Tsai (2015) (*N*=56)	iSchool graduate students in Hartel (2014a) (*N*=137)
Picture	43.8	39.7	50	52
Link diagram	28.8	39.7	23	24
Written text	14.2	7.4	9	6
Grouping diagram	9.1	10.3	11	7
Symbol	3.2	2.9	4	7
Blank	.9	0	0	2
Table	0	0	0	2
Total	100.0	100.0	100	100

When examining complexity by the ink ratio and the density of elements based on the 3 by 3 grids for each iSquare, there were more mid-level (44.8%) than low-level ones (30.1%), and only a quarter (25.1%) were identified as high-level ones. However, LIS students tended to use much more complex compositions than other students, and CS students tended to compose their iSquares in a relatively simple way ($\chi^2(4, N=219)=42.786, p<.001$). Specifically, nearly half of LIS students' iSquares (47.1%) were identified as highly complicated, and another half were mid-level. In contrast, nearly half of IM students' iSquares (49.3%) were mid-level, and about one-third (32.9%) were of low complexity. And most CS students' iSquares (48.7%) were low or mid-level in complexity (38.5%). See Table 2 and Table 4.

Table 4 Complexity of iSquares across Disciplines

Complexity	Number of Participants (*N*=219)	Percentage (%)	LIS (%) (*n*=68)	IM (%) (*n*=73)	CS (%) (*n*=78)
Low	66	30.1	5.8	32.9	**48.7**
Medium	98	44.8	**47.1**	**49.3**	38.5
High	55	25.1	**47.1**	17.8	12.8

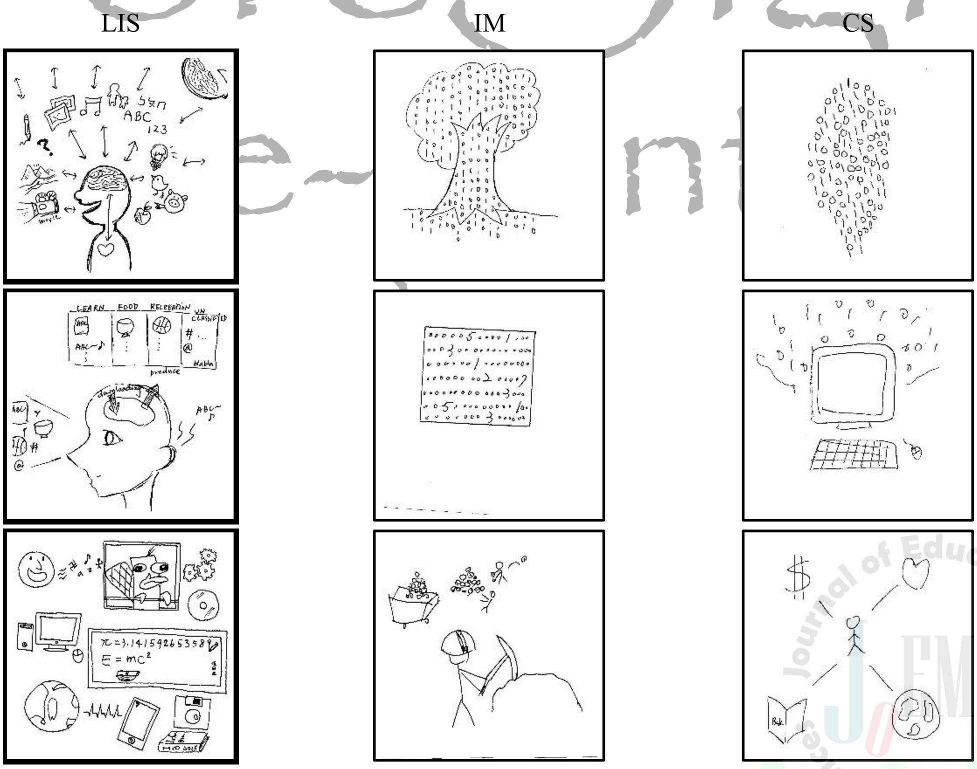
Elements in the iSquares

As to the elements students included in their iSquares, representation elements (e.g., texts, symbols), and conceptual elements (mostly as identified in Tsai, 2015) were examined.

1. Representative elements in the iSquares

Most students include some types of representative elements (such as texts, symbols, or lines) in their iSquares (86.8%). Among which, about half used texts (53.4%) or arrows/lines (50.2%), and about 30% used symbols or punctuations (30.6%). A quarter used geometric shapes (24.2%). Other representation elements include: tables or charts (15.5%), labyrinth/maze-like lines (12.8%), binary expressions or programming languages (10.5%), speech bubbles (10.5%), thought bubbles (9.1%). A few students included specific social networks with connected people (6.4%) or specific brand names or logos (e.g., Google、Yahoo、Apple、Microsoft) (4.6%), music notations/notes (3.2%), or specific textbook names or subjects (1.4%).

When further investigate the iSquares from students across fields of study, LIS students tended to include more lines or arrows (64.7%; $\chi^2(2, N=219)=8.733, p<.05$), dialog boxes (20.6%; $\chi^2(2, N=219)=11.441, p<.01$) and thought bubbles (16.2%; $\chi^2(2, N=219)=6.766, p<.05$) in their iSquares; IM and CS students tended to include binary codes (0101) or any expressions of programming languages (20.5%; $\chi^2(2, N=219)=14.622, p=.001$) in their iSquares. Some IM and CS students also included dollar signs or other representation of money; others used commercial brands, icons or logos to represent "information" (Figure 2).



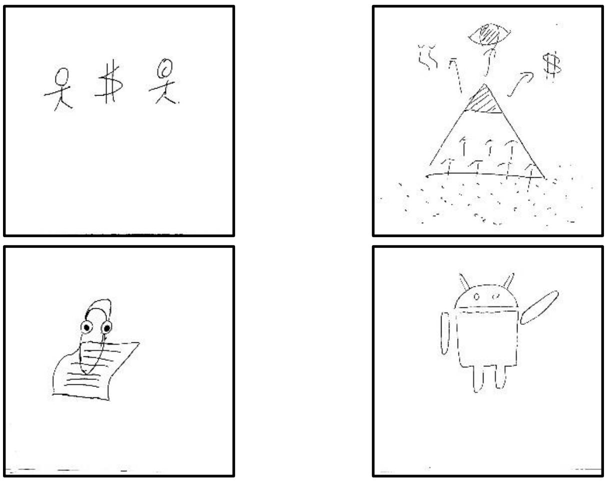


Figure 2 Sample iSquares of Representation Elements by Students in Information-Related Fields

Note 1: LIS represents library and information science; IM represents information management; CS represents computer science.

Note 2: No money signs or similar elements appeared in LIS students' iSquares; while a few LIS students used characters for metaphor (see Figure 7), no standalone iconic element appeared in LIS students' iSquares.

2. Conceptual elements in the iSquares

As shown in Table 5, nearly half of the students included the image of people (47.0%) and more than a quarter included some kind of ICT tools (27.9%). About one-fifth included print materials or artifacts (19.2%), and few included a scene (8.7%). Comparing to non-LIS counterparts, LIS students tended to express the image of people (χ^2(2, N=219)=17.460, p<.001) and print materials (χ^2(2, N=219)=11.121, p<.01). Regardless of disciplines, few students include elements that show the settings in their iSquares, so no significant difference was found regarding scenes.

Table 5 Conceptual Elements in Students' iSquares

Conceptual Elements	Number of Participants (*N*=219)	Percentage (%)	LIS (%) (*n*=68)	IM (%) (*n*=73)	CS (%) (*n*=78)
The image of people***	103	47.0	**67.6**	41.1	34.6
ICT	61	27.9	32.4	24.7	26.9
Print Materials and Artifacts**	42	19.2	**32.4**	12.3	14.1
Scenes	19	8.7	10.3	11.0	8.7

Note: ** p<.01；***p<.001

As to the image of people, students used people, body parts to present this idea (Figure 3). Two-thirds of LIS students (67.6%) used people's faces or brains to present the image of people; only less than a half of IM students (41.1%) and one-third of CS students (34.6%) present the image of people. Regardless of students' field of study, half of those who included the image of people presented "thinking" or "human interactions," and LIS students especially tended to present the idea of "thinking." LIS students also tended to present "both human and documents" or "both human and non-human sources." Very few IM and CS students presented "both human and documents" (four each) or "both human and non-human sources" (four and two each). Most CS students who presented human beings also presented a computer and/or other tools (e.g., Figure 3 CS-2). In general, LIS students included more diverse sources. Even when talking about technology, more LIS students (29.4%) than other students (11.3%) included "both human and technology" in their iSquares.

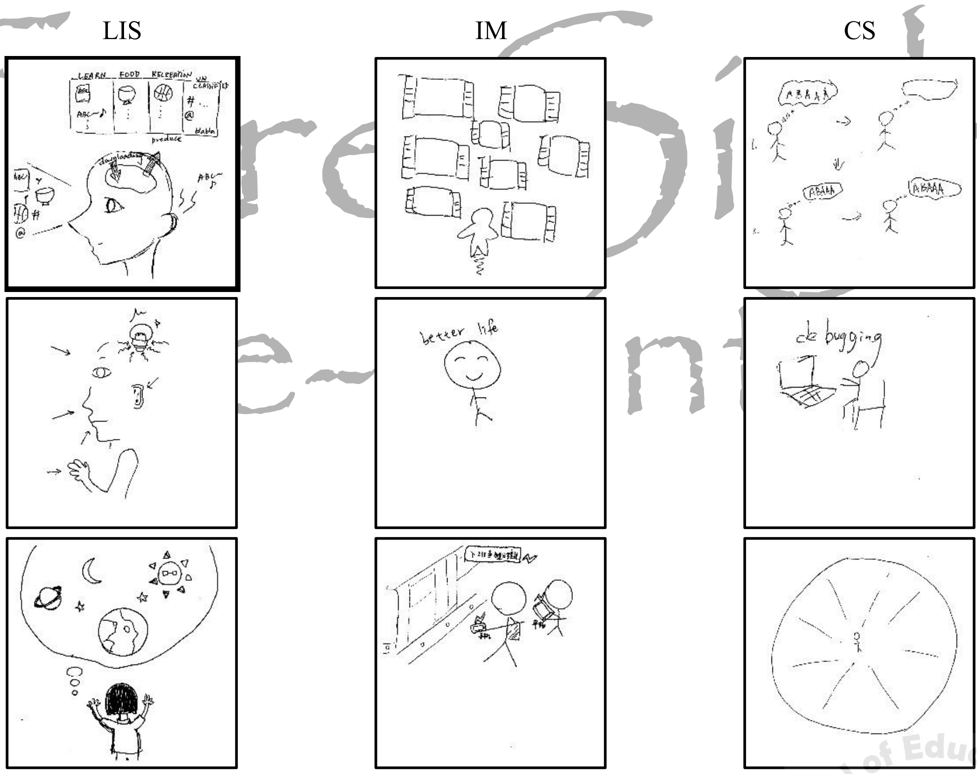


Figure 3 Sample iSquares of ICT and Print Materials by Students in Information-Related Fields

When investigating the ICT appeared in the iSquares, about 70% of students included computers, laptops, or other mobile devices in their iSquares. However, IM and CS students tended to include mobile devices (non-LIS 35.1% vs. LIS 4.5%), the

Internet or websites (non-LIS 32.4% vs. LIS 18.2%), and other electronic equipment such as the server (non-LIS 21.6% vs. LIS 9.1%). LIS students tended to include traditional media such as television and radio (LIS 27.3% vs. non-LIS 16.2%). About one-third of LIS students (33.8%) included print materials such as books, documents or magazines; only a few of non-LIS students did so (IM 12.3%, CS 14.1%). And it is interesting that all non-LIS students who include print materials also include computers, laptops, or mobile devices (Figure 4).

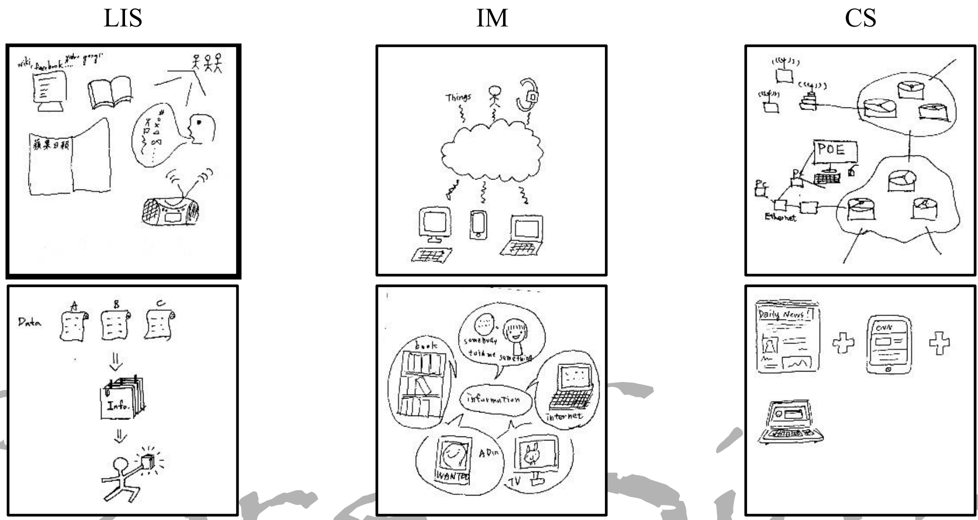


Figure 4 Sample iSquares of ICT and Print Materials by Students in Information-Related Fields

As to the few iSquares included a scene or a setting, most LIS students who included a scene presented the nature such as mountains, lakes, trees, and most CS students presented office settings. Half of the IM students who included a scene presented the nature, and the other half presented office settings. It is interesting that this may somehow reflect the nature of disciplines. LIS students tended to be more towards the humanities and used a metaphor to present the scene. Whereas, CS students tended to be more towards the sciences and thus used physical space and equipment to present the "real" scene. And IM students seem to be in between exhibiting both ways of presenting the scene.

Perspectives and meanings of the iSquares

When using Buckland's (1991) perspectives on information to discuss iSquares, about a quarter of students (25.1%) presented their iSquares from the perspective of information-as-process (Figure 5); only 10.5% presented from the perspective of information-as-knowledge (Figure 6). While many students used things to express information sources, 42.9% of the students used metaphor to present the iSquares. Since the previous section presented the findings regarding information sources, the following discussion on information-as-thing will focus on how students used "things" to do the metaphor (Figure 7).

1. Information as process

About one-third of LIS (33.8%) and IM students (32.9%), as well as 10.3% of CS students, presented the process ($\chi^2(2, N{=}219){=}14.237, p{=}.001$; Figure 5). Among which, most students (65.5%) describe the concept of information in a linear process, others (21.8%) describe a hybrid or complicated process, and few (14.5%) mentioned a circular process. These iSquares mostly implied information seeking processes or information transformation processes.

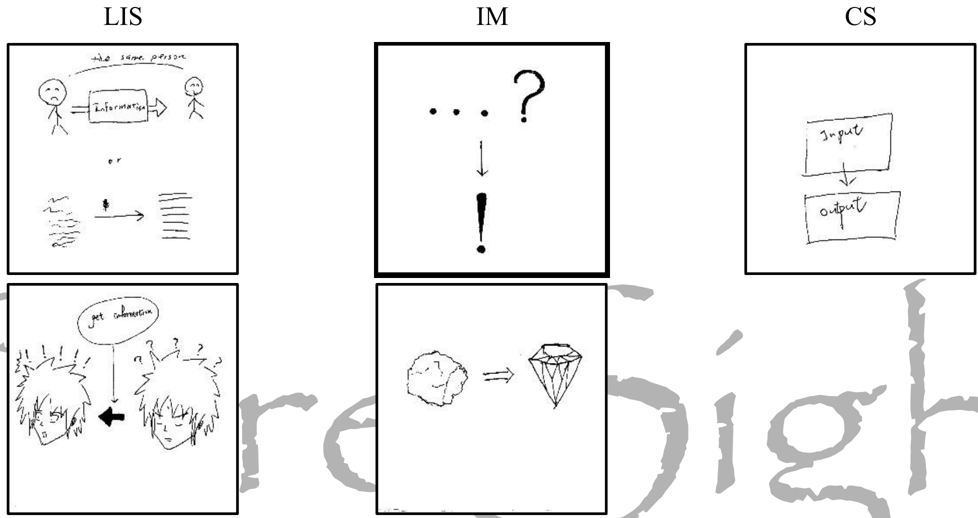


Figure 5 Sample iSquares of Information-as-Process by Students in Information-Related Fields

Note: The iSquares selected in Figure 5 emphasized a specific process from an individual's perspective (e.g., information seeking) or from a functional perspective (e.g., information transformation).

We can also find differences across disciplines when further examining the processes with the concept of information seeking. Only LIS students (19.1%) explicitly express information seeking. And while one-third of LIS students mentioned uncertainty (32.4%), only 13.7% of IM students and 6.4% of CS students mentioned this idea ($\chi^2(2, N{=}219){=}18.211, p{<}.001$). Among students who mentioned uncertainty, most of them included question marks or used texts to propose a question (70.3%); a few students used multiple options to present uncertainty (16.2%). And only LIS students (21.7% of those who expressed uncertainty) used a "gap" to present the idea of uncertainty. LIS students expressing uncertainty could come from textbook such as Case and Given (2016) who introduced Brenda Dervin's sense-making metaphor in the context of information seeking and information use.

2. Information as knowledge

Within the few students (10.5%) taking about information-as-knowledge, they typically discuss the concept of information with one of the relevant concepts in the data-information-knowledge-wisdom (DIKW) hierarchy (Table 5; Figure 6). Some also implied "information as process" with the emphasis on information transformation. However, students from different field of studies tended to use different ways of presenting information as knowledge ($\chi^2(2, N=219)=7.386, p<.05$). While LIS students (17.6%) tended to discuss multiple levels (however mostly shown in texts) or the higher level of how to turn information into knowledge, IM students (11.0%) tended to discuss the lower level regarding turning data into information. Very few CS students (3.8%) mentioned turning data to information only in texts, and thus no iSquare drawings by CS students present information as knowledge explicitly.

Table 5 iSquares Presented the DIKW Hierarchy

Hierarchy	Number of Participants (*n*=23)	Percentage (%)
Data—Information	16	69.6
Information—Knowledge/Wisdom	6	26.1
Multiple Levels (D-I-K-W)	1	4.3

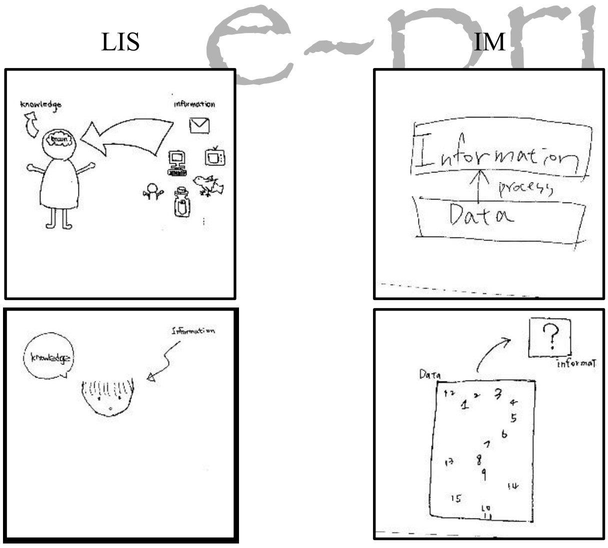


Figure 6 Sample iSquares of Information-as-Knowledge by Students in Information-Related Fields

Note: The iSquares selected in Figure 6 focused on specific concepts in the D-I-K-W hierarchy. However, no CS students presented information-as-knowledge through their iSquare drawings.

3. Information as thing

In addition to using things (e.g., mobile devices, documents) to present information sources as identified in the previous section, when viewing information as thing, students also used a metaphor to explain the idea of information. While nearly half of the students (49.3%) used metaphors to present the concept of information, students from different field of studies exhibit different in the use of metaphor. Most LIS (57.4%) and IM students (56.2%) used metaphors in their iSquares, but only slightly over one-third of CS students (35.9%) did so ($\chi^2(2, N=219)=8.746, p<.05$).

Students used over 30 different things to imply the concept of information (Figure 7), including the image of people (e.g., brains, eyes, hands, ears, hearts), animals (e.g., birds, fish, insects, spiders), plants (e.g., trees, flowers, sprouts), the nature (e.g., sun, moon, stars, clouds, the earth/globe, rocks/stones), buildings/roads/bridges, tools and items (e.g., light bulbs, glasses, containers/bottles/cups, musical instruments, transportation, weapons, keys, screwdrivers), money (e.g., coins, banknotes, dollar signs), and food (e.g., cakes, vegetables, fruits). Despite similar metaphors such as clouds (14.9%) and light bulbs (13.8%), only LIS students used bridges (3.0%), and only IM and CS students used money (13.1%), transportation such as airplanes, cars, bikes (13.1%), and weapons such as swords, guns (1.6%). Interestingly, a few LIS students used characters in animation or games to do the metaphor. For instance, one used Doraemon who owns a magic four-dimensional pocket, and one used Mario who can be powered up by the super mushroom. No matter what was used for the metaphor, students typically used positive implications to present their ideas about information.

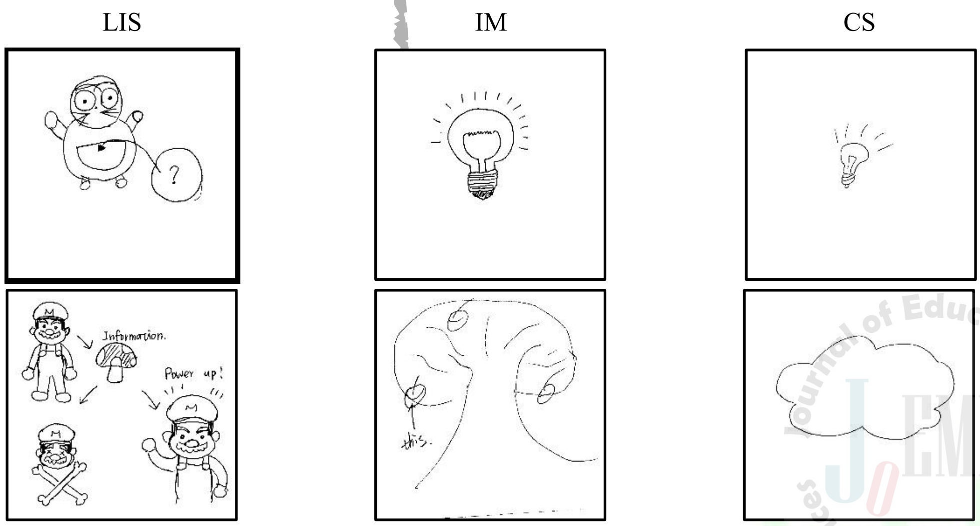


Figure 7 Sample iSquares of Information-as-Thing by Students in Information-Related Fields

Note: iSquares selected in Figure 7 used specific things (e.g., the lightbulb) for the metaphor.

Although students in the current study used some similar metaphors (e.g., lightbulbs, clouds) with what were presented in Hartel & Savolainen (2016), the LIS students in the current study seemed to use a wider range of "things" to do the metaphor.

Big Data Perspectives

When examining iSquares with the 3Vs concepts of big data—volume, velocity, and variety, 48 students who mentioned one or two big data concepts mainly came from non-LIS fields (70%), including 31.5% of IM students ($\chi^2(2, N=219)=6.776, p<.05$). Most of them mentioned the great volume of big data (77%), some mentioned the variety of information (27.1%), only a few mentioned the velocity (16.7%), and only one LIS student mentioned the velocity. See Figure 8.

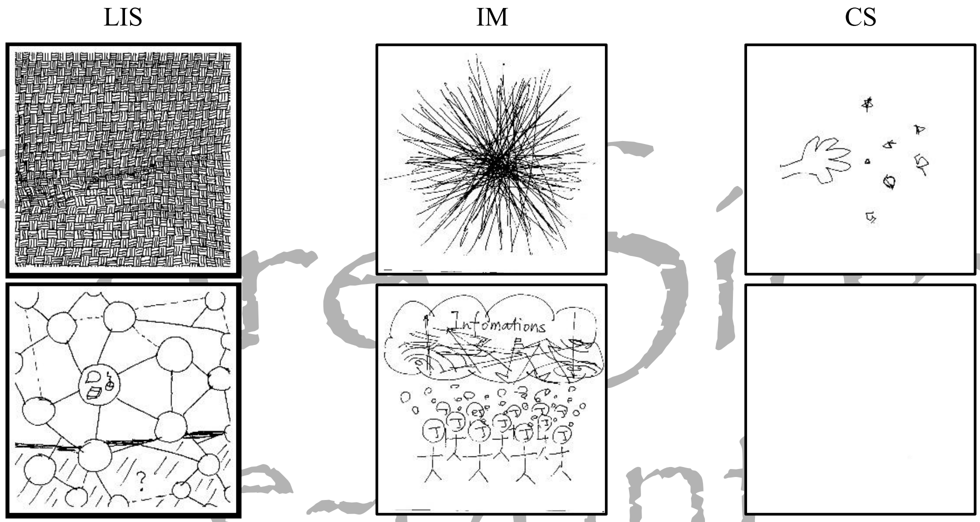


Figure 8 Sample iSquares of Big Data by Students in Information-Related Fields

Note: iSquares selected in Figure 8 highlighted the 3Vs concepts of big data—volume, velocity, and/or variety.

Discussion

Although the current study focus on students from different disciplines perceive the concept of information, the researcher also examined the effects from the level of study (undergraduate or graduate levels) in order to draw conclusions. The only differences between undergraduate and graduate students were found in using texts and metaphor, and expressing the ideas of uncertainty. Graduate students tended to use more texts, less metaphor, and express uncertainty. No significant differences were found in all the other elements or perspectives. Therefore, the following discussion focuses simply on how students from different fields of study express the concept of information in their iSquares.

LIS students tended to use link diagram with more complex compositions. Therefore, they use more arrows and lines than other students. And the representation elements included in LIS students' iSquares are also more diverse than other students. For instance, more LIS students than others used speech bubbles and thought bubbles. And resulting from the nature of the field of study as well as the different courses in each program, more IM and CS students than LIS students included binary codes or expressions of programming languages.

The different use of representation elements across disciplines could possibly be explained by the differences in students' compositions. And students' compositions somewhat reflect the nature and approaches of different disciplines. Among the three fields of study, LIS is the one closest to social sciences and humanities, and CS is on the hard-science end. Whereas, IM located in between. LIS students are trained with social science approaches, so they typically tackle issues with contexts; CS students are typically trained to find effective solutions to solve problems. Therefore, when answering a question like "what is information?" LIS students tend to include more elements to provide contexts or disclose different perspectives, and CS students tend to find a simple and elegant way to "answer" it. This phenomenon can not only be seen from their drawings but also from their texts. For instance, LIS students typically use a longer paragraph to describe what they perceive as information and explain their drawings; some CS (*n*=9) and IM students (*n*=4) consider information as the binary codes—"information is the combination of 0 and 1/is created through 0 and 1/is typically binary 0 and 1/is constructed by 0's and 1's." Among which, one CS students even stated that "information is nothing more than 0 and 1."

Textbooks reflect the nature of the three information-related fields, and these can probably further explain the differences in the conceptual elements and perspectives appeared in the iSquares. LIS students tended to include people with a wider range of sources that carry information since various areas in LIS textbooks typically introduce communication theories or information behavior theories that emphasize information channels and different sources of information, and when discussing information services, user-centered design is always one of the major concerns. And what IM and CS students learned is typically based on certain software, hardware, so they may naturally focus on the ICT devices.

Additionally, since many LIS textbooks introduce the DIKW hierarchy when defining information (e.g., Lai, 2001; Wang & Hsieh, 2014), students are more likely to mention multiple levels or emphasized how to turn information into knowledge. Since IM textbooks typically define information as meaningful messages processed from data (Chu, 2017; Loudon & Loudon, 2012), students tended to emphasized the lower level of the DIKW hierarchy. Since CS textbooks tend to introduce data structure, algorithm, etc. without formally defining information (e.g., Cormen, et al., 2009; Karumanchi, 2017), students tended to use what they learn and practice—usually things related to coding—to express the concept of information.

Another interesting thing in the same vein is that the use of icons or commercial brands also reflect the different nature of the three fields. On the more humanities end, LIS students used brand characters to do the metaphor; on the social science end, a few LIS students used commercial icons as one of the many media or sources that carry information. Unlike LIS students, some IM and CS students used one single icon that represents an information product or a specific program to express the concept of information. This well presented what information engineering might rely on because things would not functions without hardware or infrastructure, and certain information product or program may play an important role.

Conclusion

Despite that the distribution of iSquare image types is somewhat similar among students from different fields, the complexity of elements used to express the concept of information is significantly different. The perspectives of how students express "information" are also quite different. In the field of LIS, students tend to use more complex compositions and metaphor to express "information" and include people or image of people, print documents in their drawings. They also tend to express the concept of uncertainty, information-seeking processes, and the DIKW hierarchy. In contrast, IM students tend to express the concept of big data, and CS students tend to include computers, equipment, and/or concepts related to programming to express "information."

In general, students in different fields did use different elements and exhibit quite different perspectives on information. The way instructors address the concept of information may affect how students tackle issues regarding information, and thus shape the field in the future. If instructors in information-related fields are open to introduce the concept of information in fuller ranges, it can help students better understand how to position their own field of study among information-related fields. The current study provide insights for instructors to reflect on how they might want to address the concept of information.

As to future research, based on findings of the current study and Hartel (2014b), many students included the image of people in their iSquares and implies the concepts of information behavior. It would be interesting to further investigate how students' perceptions on information affect their own information behavior. This also helps iSquares evolved into a visual elicitation method.

Although Buckland's (1991) perspectives on information served as a solid foundation for the content analysis of iSquares, some of the iSquares in the current study cannot be categorized in one of the three perspectives by Buckland. This implies that iSquares research can help further expand our discussions regarding the concept of information. And while the current study provide a coding scheme for iSquare content analysis, future studies can further develop specific items in the codebook based on the current coding scheme regarding iSquares' composition, representation elements, conceptual elements, and perspectives/meanings. Since participants' drawings vary from context to context, researchers can always start with open coding before finalizing the codebook of the content analysis. Future studies can also conduct longitudinal studies comparing individuals' iSquares in order to capture individual's perspectives on the concept of information in ever-changing information practices.

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