The influence of the instruction of visual design principles on improving pre-service teachers' visual literacy

Hsin-Te Yeh, Yi-Chia Cheng

1. Introduction

To see is to believe. Since the dawn of human civilization, human beings have started to communicate and learn through what they see (Burnmark, 2002). Visualization has become an important way for human beings to learn and perceive things (Dastani, 2002). In today's information age, visualization is even more important because visual information is ubiquitous in the world as media technology rapidly grows and evolves. Visuals especially weigh more in printed materials. According to Harrison (2003), the ratio of visuals to text per page in printed documents such as fliers and reports is increasing steadily. The use of visuals in textbooks is also proliferating. Pettersson (2002) contended that there are greater numbers of pictures used in today's textbooks for each generation. In addition to books, educational media such as television, video players, and computers have been challenging people to the new way of teaching and learning that requires a clear understanding of the role of visual communication (Bustle, 2004).

Living in this visual world, the ability to understand, interpret, and create visual information seems vital. While visual materials are not automatically interpreted in the human mind, learners have to be educated to become visually literate in order to equip themselves with skills to interpret content of visual messages as well as text (Glasgow, 1994). The learned ability to understand, analyze, interpret, and create visual information is considered visual literacy (Braden, 1996; Burnmark, 2002; Burns, 2006; Lohr, 2008; Metros & Woolsey, 2006; Pettersson, 1993, 2002). Dondis (1973) described the importance of visual literacy as "what you see is a major part of what you know, and visual literacy can help us to see what we see and know what we know" (p. 19).

In the field of education, visual messages as part of teaching and learning materials can be seen in textbooks, video, pictures, and the Internet. Teachers and students are exposed to visual messages everyday. Although the use of visuals is increasing, it does not necessarily increase the effectiveness of learning. Any kind of information should be well-designed to be readable and worth reading for readers (Pettersson, 1989). Pettersson (1993) also indicated that poor design can inadvertently confuse learners, and learners may end up less competent than before. It is important to design visuals that do not mislead or confuse people. To enhance the effectiveness of teaching and learning requires both the well-designed visual instructional materials and the ability to perceive and interpret the visual messages.
According to Mayer (2001), visuals and words are good facilitators for learning if they are appropriately designed to help people construct knowledge through the cognitive process of selection, organization, and integration.

Glasgow (1994) indicated that learners have to be schooled to be visually literate in order to equip themselves with skills to interpret the content of visual messages as well as text. Averginou (2009) advocated that educators should start taking systematic steps toward including visual literacy into their teaching. Although the importance of visual literacy has been recognized, relevant higher education literature on teaching visual literacy is only now emerging (Felten, 2008). In a research effort that discussed the teaching of visual literacy, Sosa (2009) included visual design instructions such as principles of page and screen layout, use of color and font, appropriate spacing, and use of appropriate images in teaching pre-service teachers to create technology products. It was discovered that pre-service teachers' works improved dramatically in terms of look and usability. The author concluded that visual literacy truly is a missing element of many technology integration courses.

Researchers have suggested that learning visual design principles should help both designers and learners to gain ability to compose, analyze, and interpret visual materials (Carter, 2003; Graham, Hannigan, & Curran, 2005). Visual design principles such as contrast, alignment, repetition, and proximity (CARP; Lohr, 2008; Williams, 1994) have been provided and promoted to help people gain visual literacy. Pre-service teachers will become K-12 teachers who need to select or create visual materials for their teaching and to teach students how to analyze and interpret visual materials. Therefore, there was a need to know if offering pre-service teachers a visual design principles lesson would improve their ability to perceive, analyze, and interpret visual materials. Additionally, Moriarty (1996) indicated that visual intelligence has something to do with visual perception and analysis. Therefore, there was a need to know if pre-service teachers' perception and analysis of visual materials were related to visual intelligence.

1.1. The PAT Model

To appropriately design and interpret visual materials requires a great number of skills and knowledge about visual design principles. Lohr (2008) suggested that the PAT model could help people achieve the goal of designing good visual materials. PAT stands for perceptions, actions, and tools. They are three basic concepts of visual design that can improve learner perceptions by using proper tools of design with the manipulation of appropriate actions of design.

Perceptions in the PAT model refer to three principles that the human mind uses to recognize information, which are figure/ground, hierarchical, and gestalt. Actions consist of four elements recommended by Williams (2008). They are contrast, repetition, alignment, and proximity. Lohr (2008) mentioned that actions “deal with the changes or movements that have been made to instructional information or to the elements of information assembled to convey an idea” (p. 80). She concluded that actions, if applied well with the appropriate use of tools of design, could contribute to effective and professional results. As for tools, they are regarded as the basic design elements. Most designers take color, simple shape, space, depth, and typography into consideration when designing visuals (Lohr, 2008). All the tools have to be manipulated with actions to create a good visual material. There is much to explore among perceptions, actions, and tools. Nevertheless, to enhance the quality of the investigation, this study focused on the actions of visual design which are contrast, repetition, alignment, and proximity.

Contrast is used to create a difference among visual elements to make the main point of information apparent. It is utilized in visual materials to avoid elements that are similar (Williams, 2008). When designing visual materials, strong differences can be made in size, shape, color, line, thickness, and typefaces. Williams asserted that “contrast is often the most important visual attraction on a page” (p. 13).

Repetition is used to repeat some elements of the design throughout the entire piece. Repetition is commonly seen and employed in any kind of design such as headline font and size and text font and size in newsletters, books, or magazines. Repetition can also be considered as consistency, which is essential to a successful design (Williams, 2008). The purpose of repetition is to unify and strengthen the visual interest of visual materials so they are likely to be read.

Alignment is used to connect all the elements in the same visual material. Williams (2008) stated, “Nothing should be placed on the page arbitrarily. Every item should have a visual connection with something else on the page” (p. 33). Aligning elements to the left, center, right, top, or bottom could be used to create the connection among elements. Good use of alignment could unify the elements on the entire design to create a formal, fun, interesting, or sophisticated look that helps learners perceive and interpret the visual materials.

Proximity is used to organize elements in the visual materials by grouping all the related items together or separating the unrelated items. Proximity implies a relationship (Williams, 2008). When related items are grouped together, they become one visual unit, which assists learners in reading and remembering the information.

1.2. Perception, analysis, and interpretation

With the good use of actions, it would be easier for learners to perceive, analyze, and interpret visual materials to get the accurate messages that designers intend to convey (Lohr, 2008). However, to design instructional materials based on the visual design principles is one thing; how learners perceive, analyze, and interpret such materials is another. This implies the problem that learners might not be able to perceive and interpret visual materials in the way that designers expect them to do. Boling, Eccarius, Frick, and Smith (2004) argued that the intended meanings of visual materials may often be misunderstood or unrecognized by learners. This problem leads to the need of looking for ways to help learners perceive, analyze, and interpret what designers propose to convey.

Perception is organizing and analyzing information that we pay attention to in the visual world. People select the information they want to keep and ignore the rest, which is considered the first step of perception (Stern & Robinson, 1994). Pettersson (2002) indicated that experiences, values, thoughts, and knowledge are what people rely on to perceive, understand, analyze, and interpret. Therefore, perception is a subjective process. However, it does not mean that people can not learn to interpret visual materials. In fact, the process of interpreting visual information is often learned in a way similar to how people learn languages (Boling et al., 2004). That is, the ability to accurately interpret visual messages can be learned. Acquiring the skills and knowledge of visual literacy can help people analyze how visual materials are created, which contributes to people's understanding and interpretation of visual materials (Bamford, 2001; Yeh, 2008). Carter (2003) contended that learning visual design principles is a productive way to promote skills and knowledge of visual lit-
eracy. In other words, the understanding of visual design principles might improve people’s perception, analysis, and interpretation of visual materials.

1.3. Visual intelligence

In addition to the understanding of visual design principles, visual intelligence might have an influence on people’s perception and interpretation of visual materials (Moriarty, 1996). Vision is not only the passive perception of human beings but also an intelligent process of active construction (Matusitz, 2005). Visual intelligence is part of Gardner’s (1983) theory of multiple intelligences. According to Gardner (1983), visual intelligence “is the capacities to perceive the visual world accurately, to perform transformations and modifications upon one’s initial perceptions, and to be able to re-create aspects of one’s visual experience, even in the absence of relevant physical stimuli” (p. 173). Visual intelligence includes the sensitivity to color, line, shape, space, form, and the relationships exist among those elements. Gardner (1993) expressed that with appropriate instruction, encouragement, and enrichment, intelligences could be developed to a reasonably high level of performance. As for the assessment of multiple intelligences, a standardized test is not the way Gardner thought multiple intelligences should be measured. Gardner (1993) stated that assessment could be broader and more humane than just ranking people. Multiple measures such as observations, checklists, activities, chat with parents and students, and school records could be used to evaluate students’ multiple intelligences in the classrooms.

This is a world of visuals. Visual communication has become one of the important channels of communication among human beings. In the field of education, visual communication is as much a primary system as verbal language because visual aids are widely used in classrooms and teaching materials. The majority of texts that primary school students use today include the combination of written and visual elements (Simpson, 2005). Matusitz (2005) also expressed that the social context of today’s college students is more academically dependent on visual communication than in the past. The world of text is now challenged by the world of pictures (Mirzoeff, 1998). Living in the visual world, people must possess a foundation in visuals in order to understand and interpret visual messages accurately. This foundation or ability is considered visual literacy (Portewig, 2004). However, most people, especially in-service and pre-service teachers who are responsible for educating younger generations, do not have the opportunity to learn about visual literacy in schools or at the workplace. Schools should begin to introduce concepts of visual literacy and equipped students with the skills of understanding, analyzing, interpreting, synthesizing, and creating visual information (Burns, 2006).

Researchers have acknowledged the critical role of visual messages and the importance of understanding visual literacy in education. For example, Matusitz (2005) stressed the significance of understanding the elements of visual communication. Metros and Woolsey (2006) emphasized the needs for students to receive training of visual literacy. Pettersson (1990) concluded in his study that both teachers and students have to learn how to express themselves with visuals as well as how to read and use visuals. Matusitz (2005) argued that the greater skills students have in visual communication, the more effective they would be in analyzing and interpreting visual messages. The necessity of gaining and improving visual literacy, especially for teachers and students, has been addressed in prior studies. However, there has been limited effort to explore how the understanding of visual design principles influences pre-service teachers in terms of interpreting designers’ intended meanings behind visual materials. Also, while Moriarty (1996) and Matusitz (2005) asserted that visual intelligence has something to do with people’s perception, analysis, and interpretation of visuals, there has been limited relevant research conducted in the field of teacher education.

Teachers play an important role in selecting or creating instructional visual materials to help students learn. Teachers have to be visual interpreters, and sometimes they have to be visual designers too. In the teacher preparation process, it is therefore important to help pre-service teachers develop knowledge and skills of visual literacy to gain the ability of understanding visual materials appropriately. The need of empowering pre-service teachers with visual literacy is obvious. The purpose of this study was to investigate whether the instruction of visual design principles had an influence on pre-service teachers’ perception and analysis (interpretation) of visual materials in order to improve their visual literacy. Additionally, the relationship between pre-service teachers’ visual intelligence and their perception and analysis (interpretation) of visual materials was also examined. The research questions for this study included the following:

1. What were pre-service teachers’ ratings of visual materials created with the visual design principles of contrast, alignment, proximity, and repetition?
2. Did pre-service teachers’ perception of visual materials differ between those who received and did not receive the lesson of visual design principles?
3. Did pre-service teachers’ analysis (interpretation) of visual materials differ between those who received and did not receive the lesson of visual design principles?
4. Were there relationships between pre-service teachers’ perception and analysis of visual materials and their self-reported visual intelligence?

2. Methods

2.1. Participants

A convenience sample of 86 pre-service teachers who took a one-credit required course at a mid-western university participated in the study. The 86 pre-service teachers were from four intact class sections of an educational technology course taught by the first author. All of the participants were undergraduate students who plan to be elementary school teachers after they graduate. Six of the participants were male (7%); the others were female (93%). Eight students (9%) were over 25 years old and the rest of students (91%) were between 20 and 25 years old. The participants had never taken any class related to visual design or visual literacy. None of the participants was Art major. Each class section met in the classroom 1 hour each week during a 16-week semester. The enrollment of each class section was 19, 19, 20,
and 28, respectively. Consent forms were given to those who agreed to participate in the study. Some participants were absent in the weeks when data were collected, which resulted in 59 responses (69%) being included in data analysis.

2.2. Research design

This study was a nonequivalent control-group quasi-experimental design (Gall, Gall, & Borg, 2003). The four classes were randomly assigned to one treatment and one comparison group. Each group comprised two classes. The treatment group had 39 participants (45%) while the comparison group had 47 participants (55%). There were three phases of the study: pretest, treatment, and posttest. The three phases were completed in week 12, 13, and 14, respectively.

2.3. Materials

2.3.1. Powerpoint instructions

In the course, students learned to use computer programs such as Inspiration, Word, PowerPoint, Excel, Photoshop, and Dreamweaver that helped them prepare teaching materials and manage teaching. To investigate the research questions in this study, a 50-min lesson of visual design principles (contrast, alignment, repetition, and proximity) were included in the curriculum for the treatment group. A 50-min lesson of PowerPoint design principles was used in the comparison group. The two lessons were created using PowerPoint, and they were designed for a 50-min in class instruction on design principles. Both lessons comprised an introduction to actions of design, but the focuses were different. The topic of the lesson for the treatment group was "The PAT Model for Visual Design – Actions," which included 23 slides. The content of the lesson included an introduction to visual literacy, an introduction to the PAT model, and a detailed instruction of actions of visual design along with many examples for discussion. The topic of the lesson for the comparison group was “PPT Design Principles,” which included 17 slides. The content of the lesson included a brief introduction to visual literacy, an introduction to contrast, repetition, alignment, and proximity with no examples for discussion, and a detailed instruction of PowerPoint design principles. The content of both lessons was created based on the book, *The Non-Designer’s Design Book: Design and Typographic Principles for the Visual Novice* written by Robin Williams.

2.3.2. Visual intelligence self-report survey

The Visual Intelligence Self-Report Survey was used to collect data on participants’ self-reported visual intelligence and demographic information. There were 25 items in the survey. The 25 items were designed based on Gardener’s (1983) definition of visual intelligence, which included the ability to recognize instances of the same element, to create graphics, to conjure mental imagery, and to transform elements. Armstrong’s (2000) inventory for adults was also a reference for the design of the survey. All items were rated based on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). Sample statements in the survey were: (a) I pay attention to visual images while checking out the bulletin board, (b) I like drawing my feelings or emotions, (c) I often see clear visual images when I close my eyes, and (d) I think about what the visual images are trying to tell me when I see them. Principal components analysis was performed on the rating scale to see if there was a coherent factor structure. By limiting all items to one factor, factor loadings of six items were below .3. The factor could explain only 24% of variances. As for the reliability of the survey based on the responses of 59 participants, the 25 items had a Cronbach’s alpha of .81. With the acceptable reliability, we decided to keep all items and treated them as one factor – visual intelligence. However, due to the unsatisfactory percentage of explained variances, revision of the survey is suggested and required by adjusting items and running factor analysis in future study to get a better validity.

2.3.3. Visual perception test I and II

The Visual Perception Test I and II served as pretest and posttest to collect participants’ perception and analysis (interpretation) of the visual materials that comprised text and graphics manipulated with the use of visual design principles. The 12 graphics in each test were created by the first author in this study. Both tests were designed with PowerPoint. In each graphic, participants were asked to give a rating from 1 (very poor) to 5 (very good) in terms of the design, and to justify the rating they assigned. Participants’ justifications could reflect their analysis of each graphic with regard to the visual design principles used to design the graphics. In the pretest, graphics 1, 2, and 3 were designed based on the major use of contrast; graphics 4, 5, and 6 were designed based on the major use of alignment; graphics 7, 8, and 9 were designed based on the major use of repetition; graphics 10, 11, and 12 were designed based on the major use of proximity. In the posttest, graphics 1, 2, and 3 were designed based on the major use of proximity and minor use of alignment; graphics 4, 5, and 6 were designed based on the major use of repetition; graphics 7, 8, and 9 were designed based on the major use of alignment; graphics 10,
11, and 12 were designed based on the major use of contrast. Figs. 1 and 2 were sample test items. The information in Fig. 1 was hard to follow because of the bad use of proximity and alignment. In Fig. 2, all items were aligned and separated to avoid confusion (good proximity).

2.4. Procedure

2.4.1. Phase one

In week 12, participants in both treatment and comparison groups were asked to take the paper-based Visual Intelligence Self-Report Survey and the computer-based Visual Perception Test I. The process took approximately 30 min.

2.4.2. Phase two

In week 13, the treatment group received the 50-min in-class instruction of “The PAT Model for Visual Design – Actions” while the comparison group received the 50-min in-class instruction of “PPT Design Principles.” During the 50-min in-class instruction for both groups, the instructor gave many opportunities for students to think and discuss the topic to ensure that they understood the concepts. Participants were also given access to the instructions used in class for review.

2.4.3. Phase three

In week 14, participants in both groups were asked to take the computer-based Visual Perception Test II, which took about 20 min to complete. Among the 86 participants, only 59 participants (69%) completed all three phases. Data of the participants who failed to finish the three phases were eliminated from the study.

2.5. Data analysis

The answer to research question one was obtained from the Visual Perception Test I and II. To answer research question two, an independent samples t-test was performed on the data collected from the pretest to see if there was any initial difference between the treatment and comparison groups. Preferably, the two groups should have equivalent pretest means (Gall et al., 2003). Later, repeated-measures analysis of variance (ANOVA) was run to analyze the ratings of graphics from the pretest and posttest of both groups. To answer research question three, repeated-measures ANOVA was used to analyze the data collected from participants’ analysis (interpretation) of graphics in both pretest and posttest. The justifications which matched or did not match the designer’s intended meanings of design were coded as 1 and 0, respectively. As for research question four, bivariate regression was performed to analyze the data collected from the Visual Intelligence Self-Report Survey and the pretest. We chose to examine pretest but not posttest because we were interested in finding out the initial relationships between pre-service teachers’ perception and analysis of visual materials and their self-reported visual intelligence before they received the instruction of visual design principles.

![Fig. 2. Sample math test – a good design in terms of proximity and alignment.](image)

<table>
<thead>
<tr>
<th>Graphics</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pretest</td>
<td>M</td>
<td>3.8</td>
<td>2.8</td>
<td>4.1</td>
<td>3.0</td>
<td>4.0</td>
<td>3.6</td>
<td>3.8</td>
<td>3.0</td>
<td>3.4</td>
<td>1.9</td>
<td>4.1</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>1.1</td>
<td>1.1</td>
<td>0.8</td>
<td>1.0</td>
<td>0.8</td>
<td>1.2</td>
<td>0.8</td>
<td>1.2</td>
<td>0.9</td>
<td>0.9</td>
<td>1.0</td>
</tr>
<tr>
<td>Posttest</td>
<td>M</td>
<td>2.8</td>
<td>3.8</td>
<td>3.9</td>
<td>2.5</td>
<td>2.6</td>
<td>4.5</td>
<td>4.0</td>
<td>4.4</td>
<td>3.1</td>
<td>3.4</td>
<td>3.3</td>
</tr>
<tr>
<td></td>
<td>SD</td>
<td>0.9</td>
<td>1.0</td>
<td>1.0</td>
<td>1.1</td>
<td>1.0</td>
<td>0.9</td>
<td>0.9</td>
<td>0.9</td>
<td>1.0</td>
<td>1.2</td>
<td>1.0</td>
</tr>
</tbody>
</table>
3. Results

For research question one, Table 1 presented the means and standard deviations of students' ratings of the graphics in pretest and posttest. The three highest scores in the pretest were graphics 11 (M = 4.1), 3 (M = 4.1), and 5 (M = 4.0), which were designed with the use of proximity, contrast, and alignment, respectively. The three highest scores in the posttest were graphics 6 (M = 4.5), 8 (M = 4.4), and 7 (M = 4.0), which were designed with the use of repetition (graphic 6) and alignment (graphics 8 and 7). Overall, graphics designed with the use of alignment in both pretest (graphics 4, 5, and 6) and posttest (graphics 7, 8, and 9) had the highest average scores of 3.5 and 3.9, respectively. In the pretest, graphics designed with the use of contrast also had an average score of 3.5 (graphics 1, 2, and 3). The second highest average score (M = 3.5) in the posttest was graphics designed with the use of proximity (graphics 1, 2, and 3).

For research question two, an independent samples t-test was run to see if there was any initial difference between the treatment and comparison groups in the pretest. There was no significant difference at the alpha level of .05, t(57) = -.54, p = .59. This result provided justification for continuing the research. Repeated-measures ANOVA was used to determine whether the pretest–posttest difference of the treatment group was significantly different from the pretest–posttest difference of the comparison group in terms of students' perception of the graphics. The result indicated that there was no significant difference in terms of the group (treatment and comparison) by change interaction effect at the alpha level of .05, as shown in Table 2. The comparison group had a higher initial mean score than the treatment group, but the slope of the treatment group was larger than the comparison group (see Fig. 3). Descriptive statistics for the treatment and comparison groups on students' perceptions of the graphics are summarized in Table 3.

For research question three, repeated-measures ANOVA was used to determine whether the pretest–posttest difference of the treatment group was significantly different from the pretest–posttest difference of the comparison group in terms of students' analysis (interpretation) of the graphics. The result indicated that there was a significant difference in terms of the group by change interaction effect at the

Table 2
Repeated-measures ANOVA table for the interaction effect on students' perceptions of the graphics.

<table>
<thead>
<tr>
<th>Source</th>
<th>Change</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>Linear</td>
<td>.274</td>
<td>1</td>
<td>.274</td>
<td>3.049</td>
<td>.086</td>
</tr>
<tr>
<td>Change * group</td>
<td>Linear</td>
<td>.168</td>
<td>1</td>
<td>.168</td>
<td>1.874</td>
<td>.176</td>
</tr>
<tr>
<td>Error (change)</td>
<td>Linear</td>
<td>5.115</td>
<td>57</td>
<td>.090</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Fig. 3. Group by change interaction in terms of students’ perceptions of the graphics. 1 was pretest and 2 was posttest on the X-axis.

Table 3
Descriptive statistics for the treatment and comparison groups on students' perceptions of the graphics.

<table>
<thead>
<tr>
<th>Group</th>
<th>Test</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>Pretest</td>
<td>3.28</td>
<td>.25</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>3.46</td>
<td>.35</td>
</tr>
<tr>
<td>Comparison</td>
<td>Pretest</td>
<td>3.32</td>
<td>.27</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>3.34</td>
<td>.31</td>
</tr>
</tbody>
</table>

Table 4
Repeated-measures ANOVA table for the interaction effect on students' analysis (interpretation) of the graphics.

<table>
<thead>
<tr>
<th>Source</th>
<th>Change</th>
<th>Type III sum of squares</th>
<th>df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change</td>
<td>Linear</td>
<td>.401</td>
<td>1</td>
<td>.401</td>
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<td>.000</td>
</tr>
<tr>
<td>Change * group</td>
<td>Linear</td>
<td>.422</td>
<td>1</td>
<td>.422</td>
<td>27.154</td>
<td>.000</td>
</tr>
<tr>
<td>Error (change)</td>
<td>Linear</td>
<td>.886</td>
<td>57</td>
<td>.016</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
alpha level of .05, as shown in Table 4. The comparison group had a higher initial mean score than the treatment group, but the slope of the treatment group was larger than the comparison group (see Fig. 4). In addition, the slope of the comparison group was slightly negative. Descriptive statistics for the treatment and comparison groups on students’ analysis (interpretation) of the graphics are summarized in Table 5.

Table 5
Descriptive statistics for the treatment and comparison groups on students’ analysis (interpretation) of the graphics.

<table>
<thead>
<tr>
<th>Group</th>
<th>Test</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment</td>
<td>Pretest</td>
<td>.31</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>.36</td>
<td>.14</td>
</tr>
<tr>
<td>Comparison</td>
<td>Pretest</td>
<td>.55</td>
<td>.19</td>
</tr>
<tr>
<td></td>
<td>Posttest</td>
<td>.35</td>
<td>.17</td>
</tr>
</tbody>
</table>

Table 6
Descriptive statistics for the visual intelligence self-report survey and perception and analysis of visual materials in pretest.

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>M</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Survey</td>
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<td>3.52</td>
<td>.38</td>
</tr>
<tr>
<td>Perception</td>
<td>59</td>
<td>3.30</td>
<td>.26</td>
</tr>
<tr>
<td>Interpretation</td>
<td>59</td>
<td>.33</td>
<td>.14</td>
</tr>
</tbody>
</table>

Note. Survey and perception items ranged from 1 to 5; interpretation items ranged from 0 to 1.

For research question four, bivariate regression was used to analyze the relationships between visual intelligence and perception and analysis (interpretation) of visual materials. Table 6 represented the means and standard deviations of the Visual Intelligence Self-Report Survey and students’ perception and analysis (interpretation) of visual materials in the pretest.

The result of the bivariate regression indicated that the independent variable (visual intelligence) could only predict 2.3% of variance in the dependent variable (visual perception), $R^2 = .02, F(1, 57) = 1.31, p > .05$. In terms of students’ analysis (interpretation), the independent variable (visual intelligence) could only predict .4% of variance in the dependent variable (visual interpretations), $R^2 = .004, F(1, 57) = .24, p > .05$. Neither of the relationships was statistically significant.

4. Discussions

This study explored the influence of the instruction of visual design principles on pre-service teachers’ perception and analysis (interpretation) of visual materials. We also examined whether there were relationships between pre-service teachers’ visual intelligence and their perception and analysis (interpretation) of visual messages. From the result of students’ ratings on the graphics, we discovered that they perceived better the graphics designed with the use of alignment and contrast. In the posttest, although graphics designed with the use of proximity had the second highest average score, students actually classified the graphics as those designed with the use of alignment in their justifications. In fact, it is easy to confuse the use of proximity with the use of alignment. For example, all the items spread out on the same page might be regarded as bad use of proximity. However, it could be also regarded as no use of alignment.

While Williams (2008) pointed out that alignment can always be seen in any kind of design, it was not surprising to find that pre-service teachers were sensitive to graphics designed with the use of alignment. This finding might also have something to do with human reading habits and eye movements. People are used to reading from left to right because aligning to the left creates an invisible line to lead people’s eye movements (Krug, 2006; Yeh, 2008). If something is not well-aligned, it is easy to notice because of the uncomfortable eye movements. Moreover, Williams also noted that contrast is usually the most important visual attraction on a page. This explains why pre-service teach-
ers were sensitive to graphics designed with the use of contrast because it was easy for them to notice the difference in the graphics. Differences catch people’s eyes since they are outstanding.

Goldsmith (1984) and Pettersson (1993, 2002) indicated that experiences, values, thoughts, and knowledge are what people rely on to perceive, understand, and interpret. Therefore, understanding visual design principles is one only of the factors that influence pre-service teachers’ perception of visual materials. This might be the reason why there was no significant difference in the group by change interaction effect in terms of students’ perceptions of the graphics. In addition, pre-service teachers’ ratings of the graphics were conservative. Not many of them gave extreme low ratings such as 1, which might explain why the difference was not significant. Most pre-service teachers in both treatment and comparison groups had similar ratings for graphics designed with the use of alignment and contrast because they were sensitive to those two actions. This could also be the reason why the difference was not significant.

The significant difference in the group by change interaction effect in terms of pre-service teachers’ analysis (interpretation) of visual materials suggested a positive influence of the instruction of visual design principles. In other words, understanding visual design principles could contribute to more accurate analysis (interpretation) of visual materials. This finding echoes many prior research findings which suggested that knowledge of visual design principles promotes interpretation of visual materials (Carter, 2003; Portewig, 2004; Yeh, 2008). That is, understanding visual design principles of contrast, repetition, proximity, and alignment could improve pre-service teachers’ analysis (interpretation) of visual materials. Likewise, familiarizing with other visual design principles such as perceptions and tools could also improve pre-service teachers’ analysis (interpretation) of visual materials. This provides an avenue for future study.

The result of the bivariate regression revealed that there was no relationship between pre-service teachers’ perception and analysis of visual materials and their self-reported visual intelligence. This finding contradicted Matusitz’s (2005) assertion that visual intelligence has something to do with perception, analysis, and interpretation. There are many other factors that might influence people’s perception, analysis, and interpretation of visual materials. Using visual intelligence as the sole factor to predict students’ perception and analysis (interpretation) could not result in a satisfactory outcome in this case. Maybe the result would be different if there were other subscales of visual intelligence that could be used as predictors, and if the validity of the Visual Intelligence Self-Report Survey could be improved. Further research can examine other factors to determine if there are better predictors of perception and analysis of visual materials.

There are several limitations that limit the generalizability of this study. First, the sample size was not big enough for statistical analysis. Second, the graphics used for the pretest and posttest were created by one designer without confirmation with other professionals. Third, the Visual Intelligence Self-Report Survey did not specify the subscales and the percentage of explained variance was low. Fourth, due to the time constraint, there was no test to ensure that students understood the visual design principles after the treatment. Fifth, the time interval of the pretest, treatment, and posttest was too short to determine the influence of retaining the knowledge of visual design principles. Last, this study investigated only the actions of visual design principles, not the whole PAT model. All the limitations should be taken into consideration in future study.

5. Conclusion

Visual literacy plays an important role in this information age where visual messages are pervasive. Visual literacy is the ability to read and write visual materials. In other words, visual literacy is a complex of knowledge, capacities, and skills that a person develops in the visual mode (Shiau, 1989). The knowledge, capacities, and skills could be learned to enhance visual literacy. The findings in this study implied that incorporating the instruction of visual design principles in the educational technology curriculum for pre-service teachers provided a good opportunity to improve their visual literacy. Living in this visual world, people need the ability to visually communicate with each other. Pre-service teachers will become those who can influence the next generation to survive the future. Therefore, visual literacy is suggested to be included in the curriculum in order to equip pre-service teachers with the competence to create effective visual instructional materials, help students understand and analyze instructional visuals, and pass on knowledge and skills of visual literacy to their students—the next generation.

References


